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SUMMER 1993

REPORT NO. 94-21

U.S. ARMY NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER (NRDEC) SOLAR RADIATION TESTS ON MILVAN SHIELDING IN KUWAIT

Prepared for:
U.S. Army Natick Research, Development and Engineering Center
ATTN: SATNC-USOS
Natick, MA 01760-5017

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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by U.S. Army Natick Research, Development and Engineering Center (NRDEC) to conduct engineering tests on solar radiation covers that can be used over Military Vans (MILVANs) to protect ammunition. These tests monitored interior and exterior temperatures of protected and unprotected MILVANs. Tests were conducted at an ammunition supply point (ASP) in Kuwait during the summer of 1993, the results are contained in this report.

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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
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JULY - SEPTEMBER 1993

TABLE OF CONTENTS

PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by U.S. Army Natick Research, Development and Engineering Center (NRDEC) to conduct engineering tests on solar radiation covers that can be used over Military Vans (MILVANs) to protect ammunition. These tests monitored interior and exterior temperatures of protected and unprotected MILVANs. Tests were conducted at an ammunition supply point (ASP) in Kuwait during the summer of 1993.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of this test was to determine the effectiveness of MILVAN solar radiation covers at protecting ammunition openly stored in MILVANs.

D. CONCLUSION. All tests conducted to date indicate that the NRDEC cover is slightly better at reducing MILVAN exterior temperatures and dissipating heat versus the tin roof over the MILVAN. The NRDEC design was also very effective at reducing solar loading on the interior and thermal stress being applied to the ammunition. Of interest during this test was the shielding effectiveness of the tin roof. Although slightly less effective than the NRDEC tarpaulin, it is a very suitable alternative for solar shielding as a field fix for protecting the ammunition. It should also be noted that although the NRDEC tarpaulin was better than the tin roof, it is more susceptible to high winds and requires higher maintenance. Periodic retightening of the tarpaulin, stakes, and poles is necessary. The tarpaulin also requires a larger area due to its footprint; as such, it is not the ideal solar radiation cover.

E. RECOMMENDATION. Additional tests should be conducted on second generation tarpaulins and covers that eliminate the disadvantages of the NRDEC design such as form-fitted MILVAN solar radiation covers.

PART 2

JULY - SEPTEMBER 1993

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PART 3

TEST PROCEDURES

MILVANs were loaded with live ammunition to depict "real world" open storage conditions. One MILVAN was unprotected and used as the control with two additional MILVANs used, one covered with a tin roof and one covered with a NRDEC II design tarpaulin. Thermal couples were placed in all MILVANs at the following locations:

a. On the MILVAN roof (exterior).

b. MILVAN interior, 6 inches below the roof.

c. On top of the ammunition load.

The MILVAN doors were closed with temperature readings taken every 5 minutes. Ambient temperature and humidity were also monitored throughout the test with the test lasting 3 months (see photos for test setup).

PART 4

TEST EQUIPMENT

A. TEST MILVAN CONTAINERS.

1. Quantity.	3
2. Type.	End-opening MILVANs
3. Weight.	40,000 pounds (approximately)
4. Cube.	1,280 cubic feet

B. WEATHER STATION.

1. Manufacturer.	Climatronics
2. Number of channels.	64
3. Type of probe.	Thermocouple

C. DATA LOGGERS.

1. Manufacturer.	ACR
2. Number of channels.	2
3. Type of probe.	Thermistor

PART 5

TEST RESULTS

The three test samples used during this evaluation are as follows:

A. The first MILVAN had a single-layer open-mesh tan fabric on all four sides with a second layer of black open-mesh underlayment over the MILVAN roof. This tarpaulin has been referred to in other USADACS reports as NRDEC II design.

B. The second MILVAN had a 2- by 4-inch wooden frame constructed 18 inches above the MILVAN roof and covered with standard corrugated sheet metal roofing. This design afforded no sidewall protection and appeared to be ineffective; however, due to the MILVAN configurations in Kuwait, the long sides were oriented north and south with MILVANs stacked next to each other with solar radiation exposure only to the door areas of the MILVANs and the east and west walls of the two outside MILVANs at the end of the rows.

C. The third MILVAN had no protection and was used as the control or "worst case" scenario.

TABLE 1

MILVAN

Peak Temperatures (F.)

Julian Date	Test Sample	Ambient Temperature	MILVAN Roof	Inside 6-Inches Down	Top of Load
099 - 130	Control	104	149	132	121
(110)	Tin Roof		116	108	98
	NRDEC II		114	109	98

TABLE 1 (continued)

MILVAN

Peak Temperatures (F.)

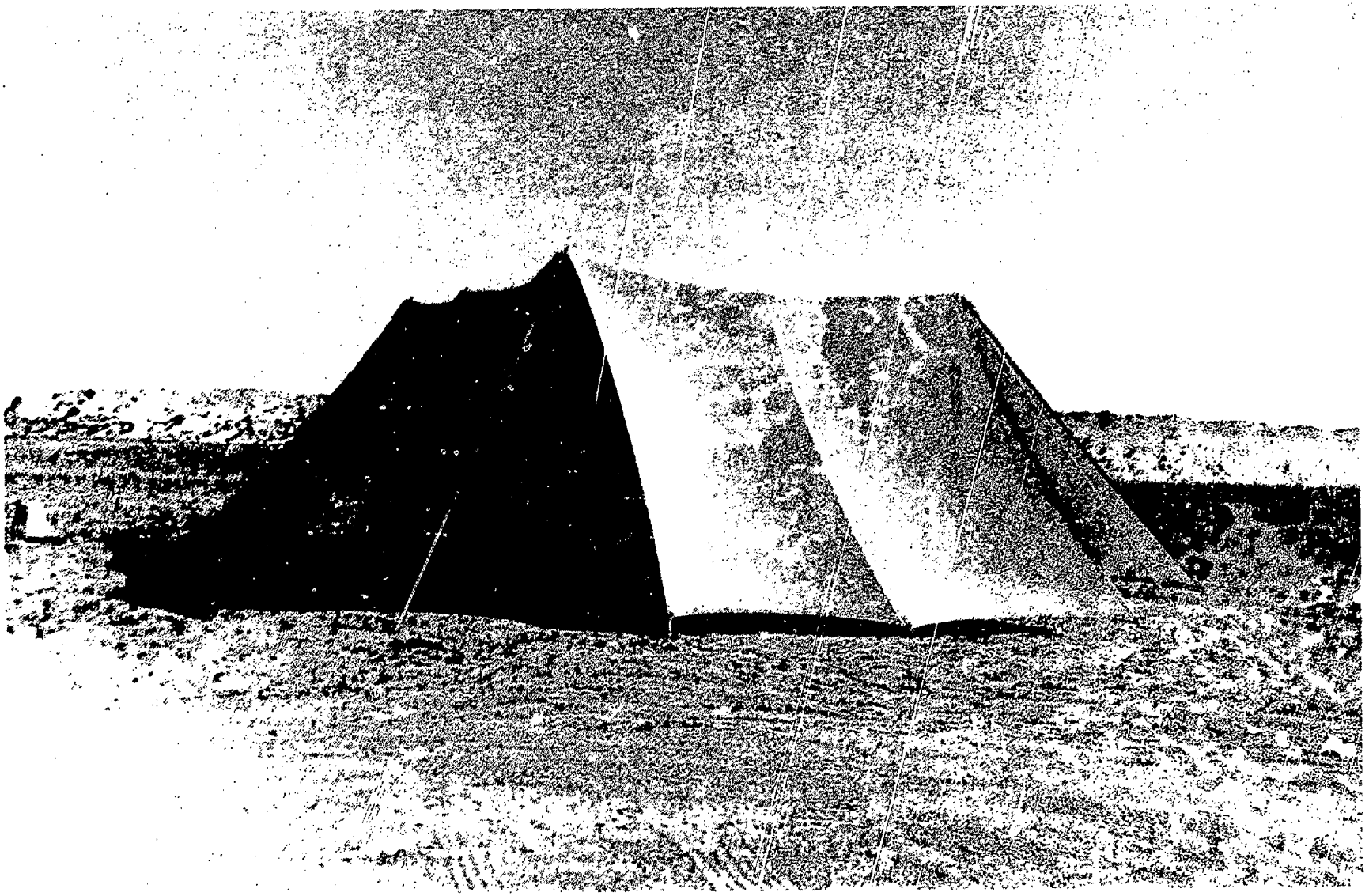
Julian Date	Test Sample	Ambient Temperature	MILVAN Roof	Inside 6-Inches Down	Top of Load
131 - 160	Control	115	156	140	120
(159)	Tin Roof		119	115	108
	NRDEC II		116	118	105
161 - 190	Control	105	153	138	116
(174)	Tin Roof		109	124	108
	NRDEC II		111	113	97
191 - 220	Control	114	158	145	124
(217)	Tin Roof		124	126	108
	NRDEC II		120	121	102
221 - 256	Control	118	164	150	130
(221)	Tin Roof		129	136	111
	NRDEC II		126	125	107

The Julian date in parenthesis is when the maximum MILVAN exterior temperature occurred. From April 9 - June 9 very little advantage or disadvantage could be noted for the NRDEC tarpaulin versus the tin roof. All reported peak readings were within 3 degrees Fahrenheit of each other. From June 10 - September 13 the roof temperatures still remained fairly close with the NRDEC tarpaulin showing slightly greater temperature reductions. Greater temperature reductions were noted on the NRDEC MILVAN interior temperatures 6 inches from the roof as well as on the load itself, with the NRDEC tarpaulin temperature being consistently lower than the tin roof temperature; i.e., the NRDEC tarpaulin reduced interior temperatures 6 inches below the roof by an average of 9 degrees Fahrenheit and on top of the

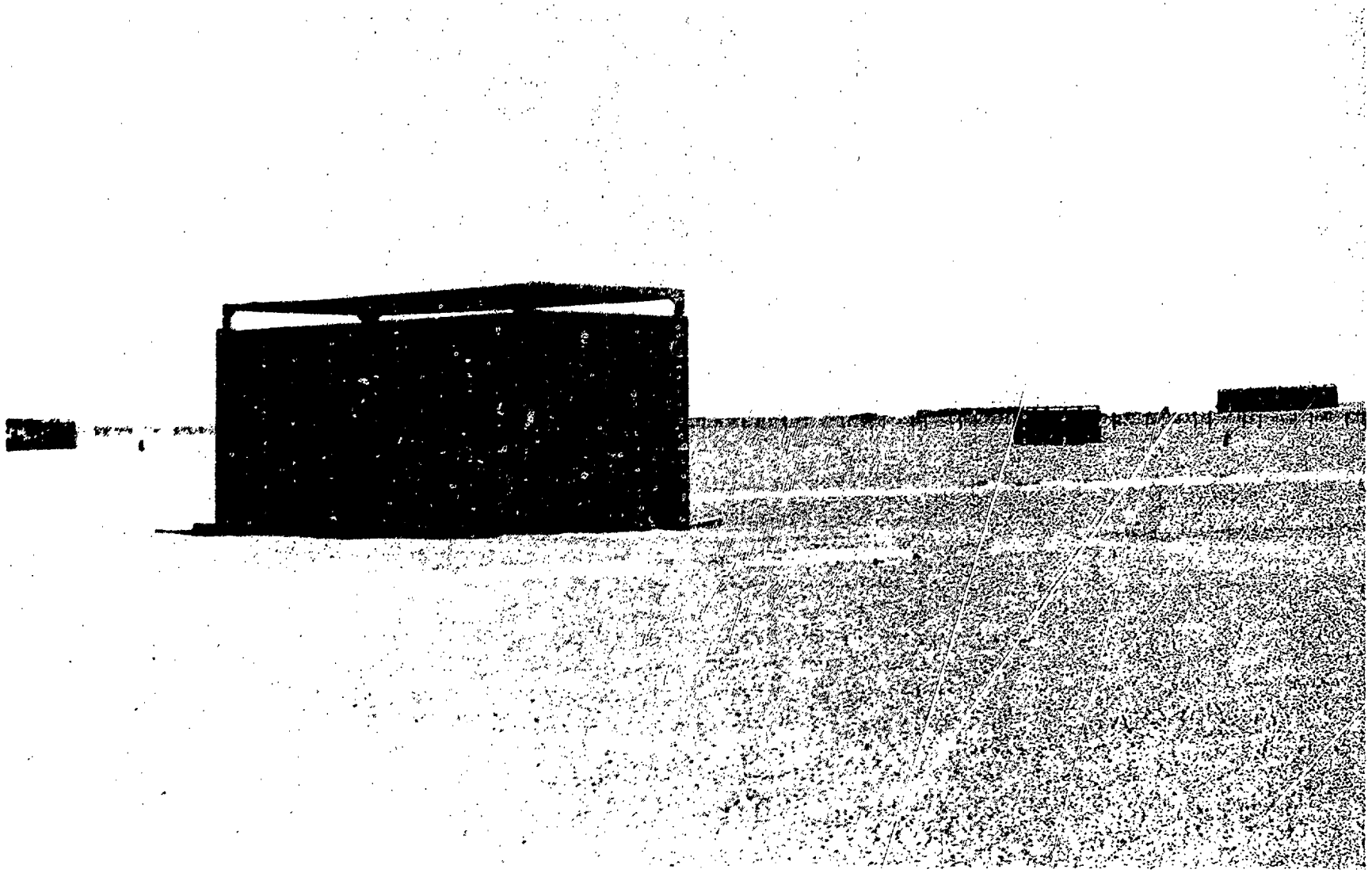
load by 7 degrees Fahrenheit over the tin-covered MILVAN. The NRDEC tarpaulin reduced interior temperatures 25 degrees Fahrenheit 6 inches from the roof and 21 degrees Fahrenheit on top of the load versus the unprotected MILVAN. Note that the ambient temperature reported is not necessarily the peak temperature for the time period; however, it was the ambient temperature at the time when maximum solar loading on the test items occurred. Conditions that cause this to occur include bright/clear days, little or no overcast, little or no wind speeds, and moderately high ambient temperatures.

PART 6

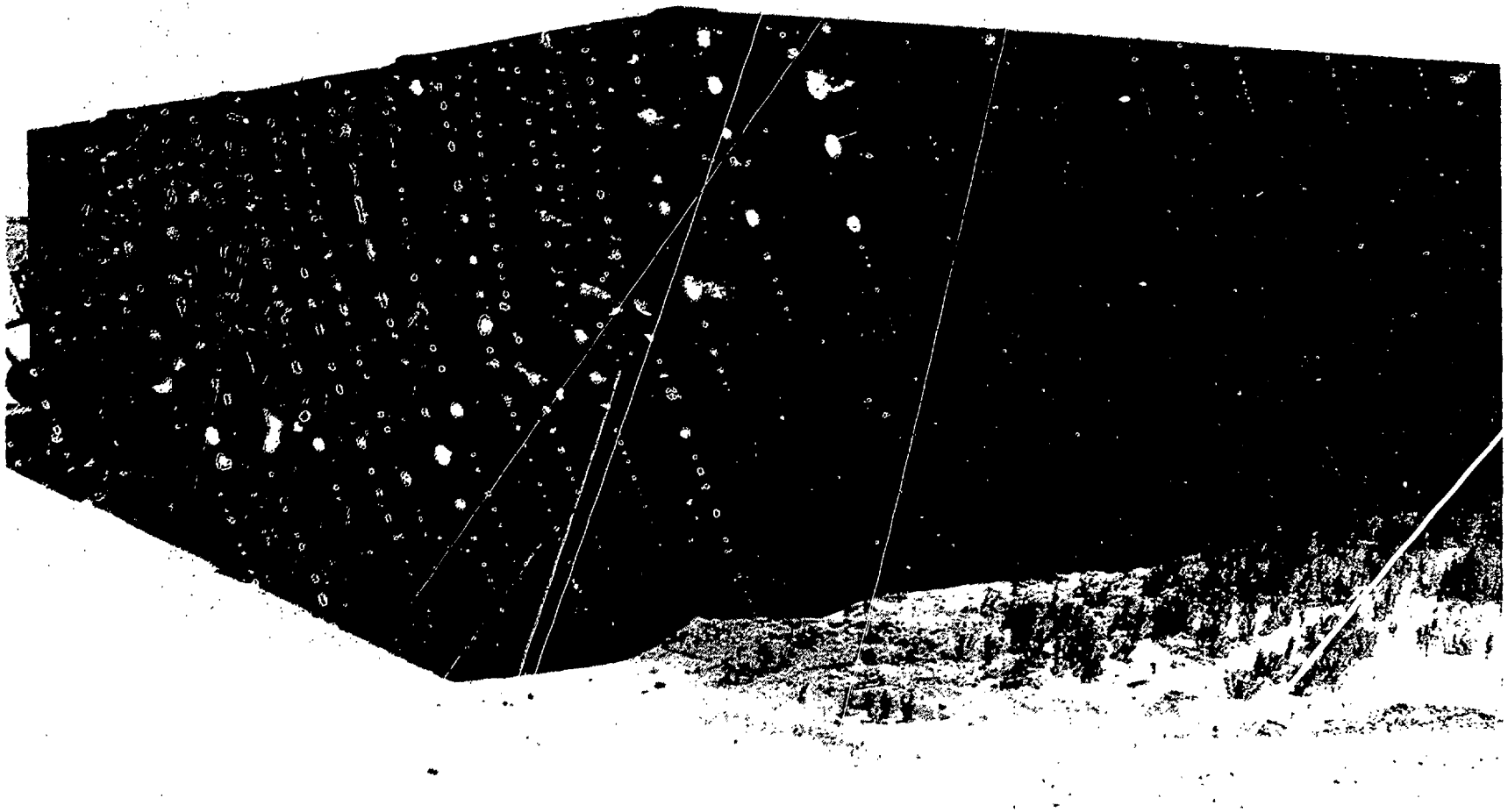
PHOTOGRAPHS



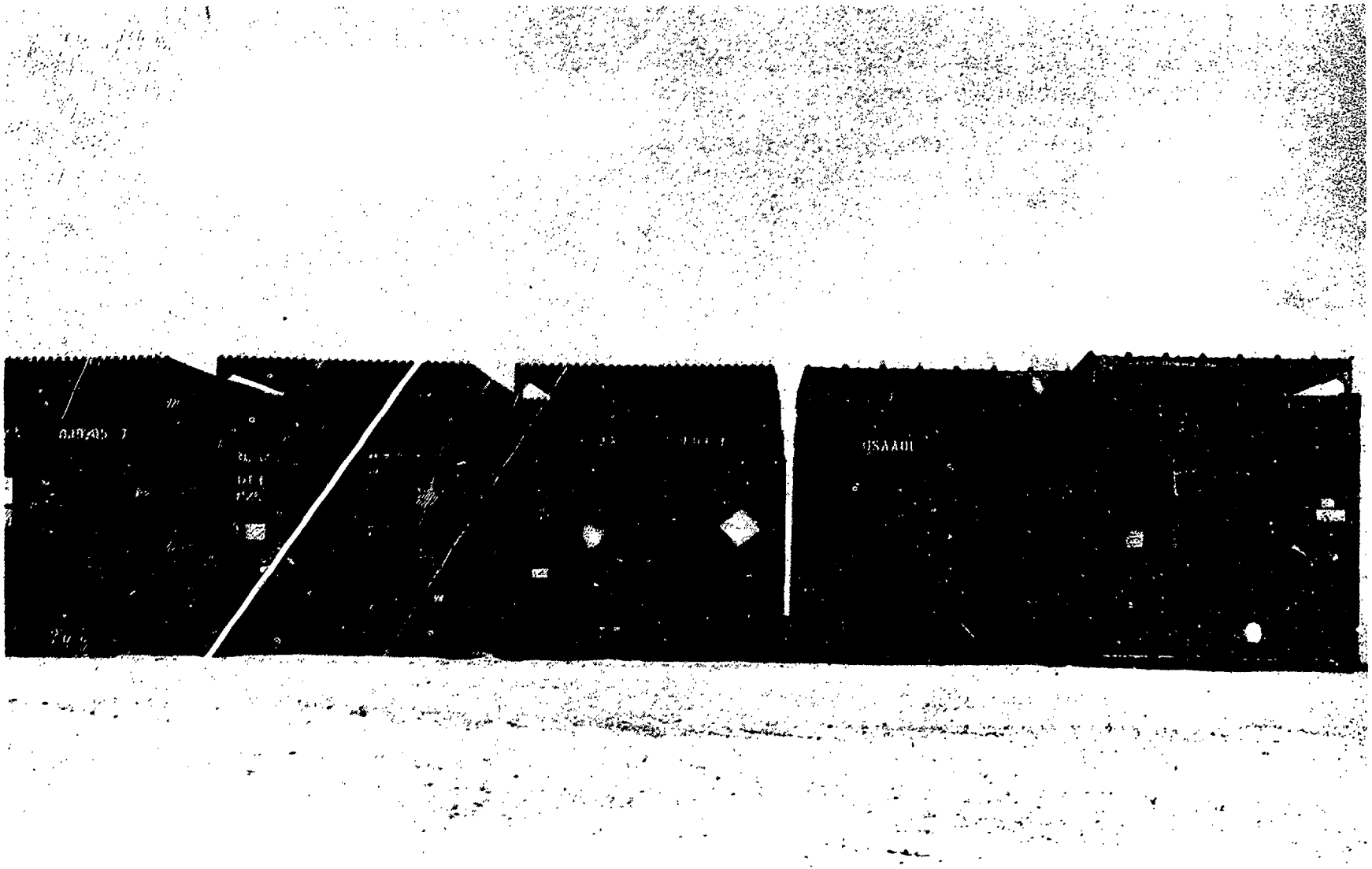
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
PHOTO NO. A0317: This photo shows the test setup of the NRDEC II tarpaulin located at the ASP in Kuwait.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
PHOTO NO. AO317-SCN-92-3B4-3421: This photo shows a MILVAN used to compare the NRDEC II tarpaulin during this evaluation. Note that the tin roof is elevated 18 inches above the MILVAN roof.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
PHOTO NO. A0317: This photo shows the control MILVAN used during testing with no solar shielding protection.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
PHOTO NO. AO317-SCN-92-334-3419: This photo shows a typical configuration of MILVANs with tin roofs stacked next to each other, located at the ASP in Kuwait.		

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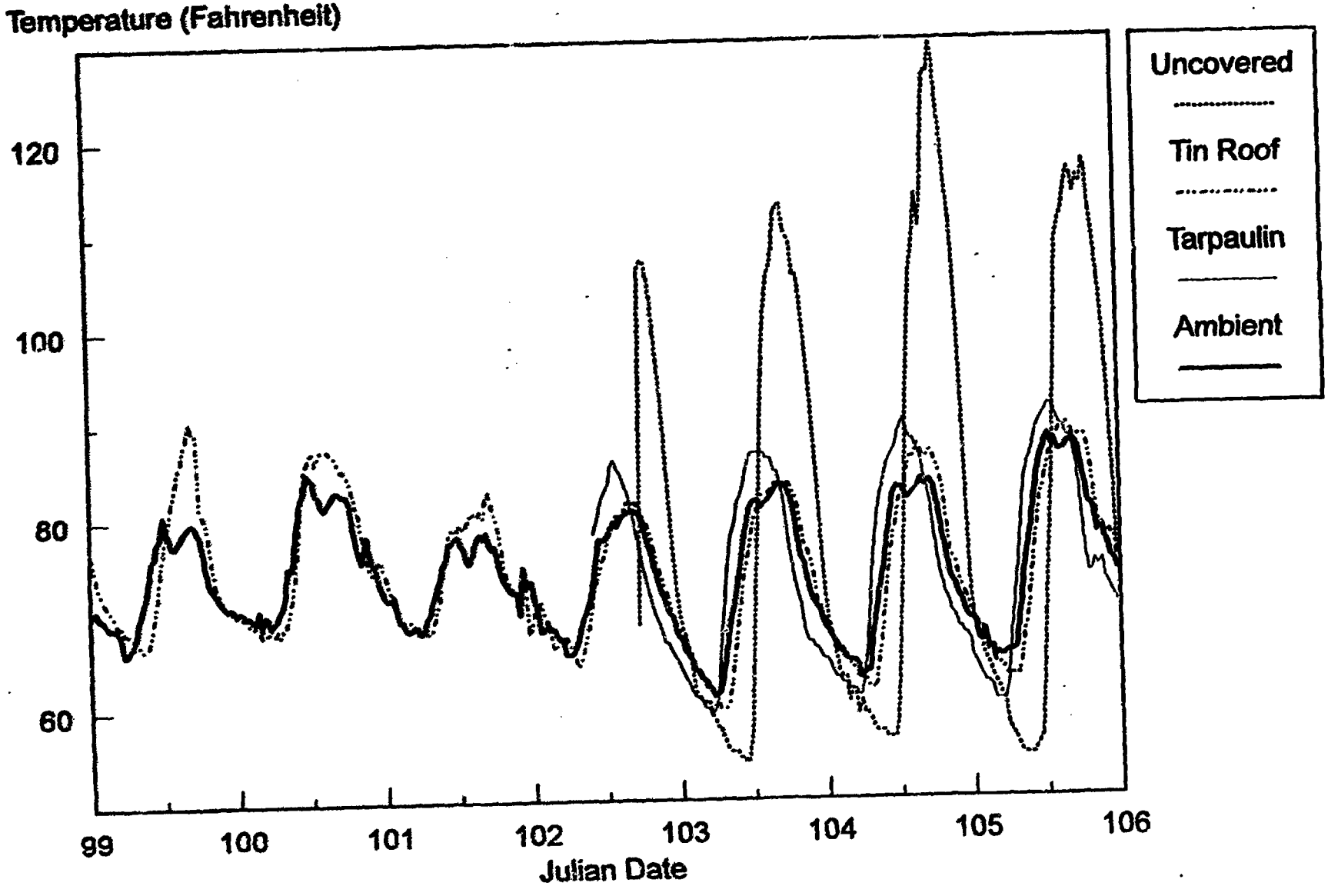
PHOTO NO. A0317: This photo shows the weather station that recorded environmental conditions during the NRDEC test. Note the MICOM missiles in the foreground. This test was being conducted at the same time as the tarpaulin evaluation.

PART 7

GRAPHS


Top of MILVAN
Temperature (Fahrenheit)
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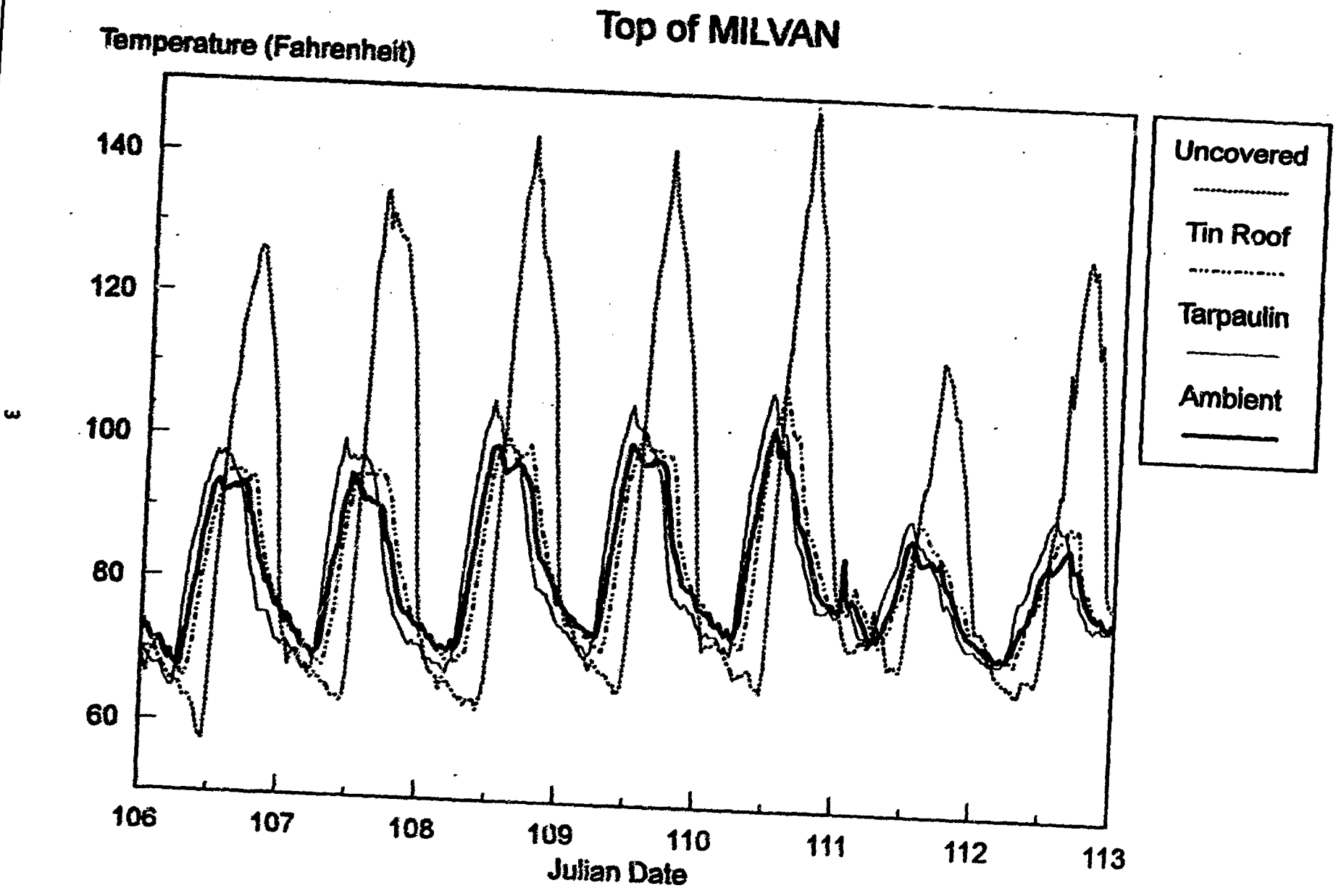
106
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of MILVAN
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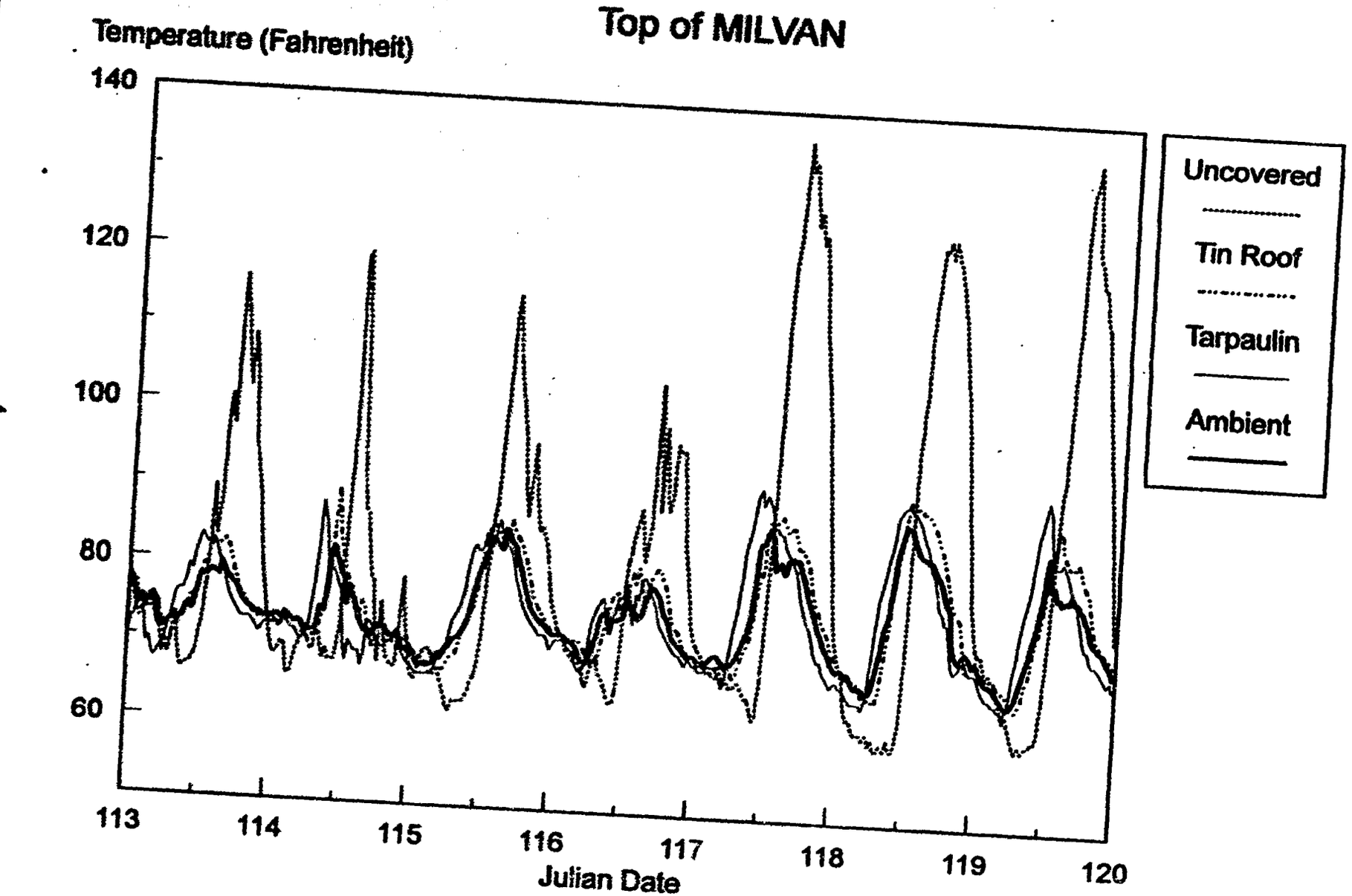
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient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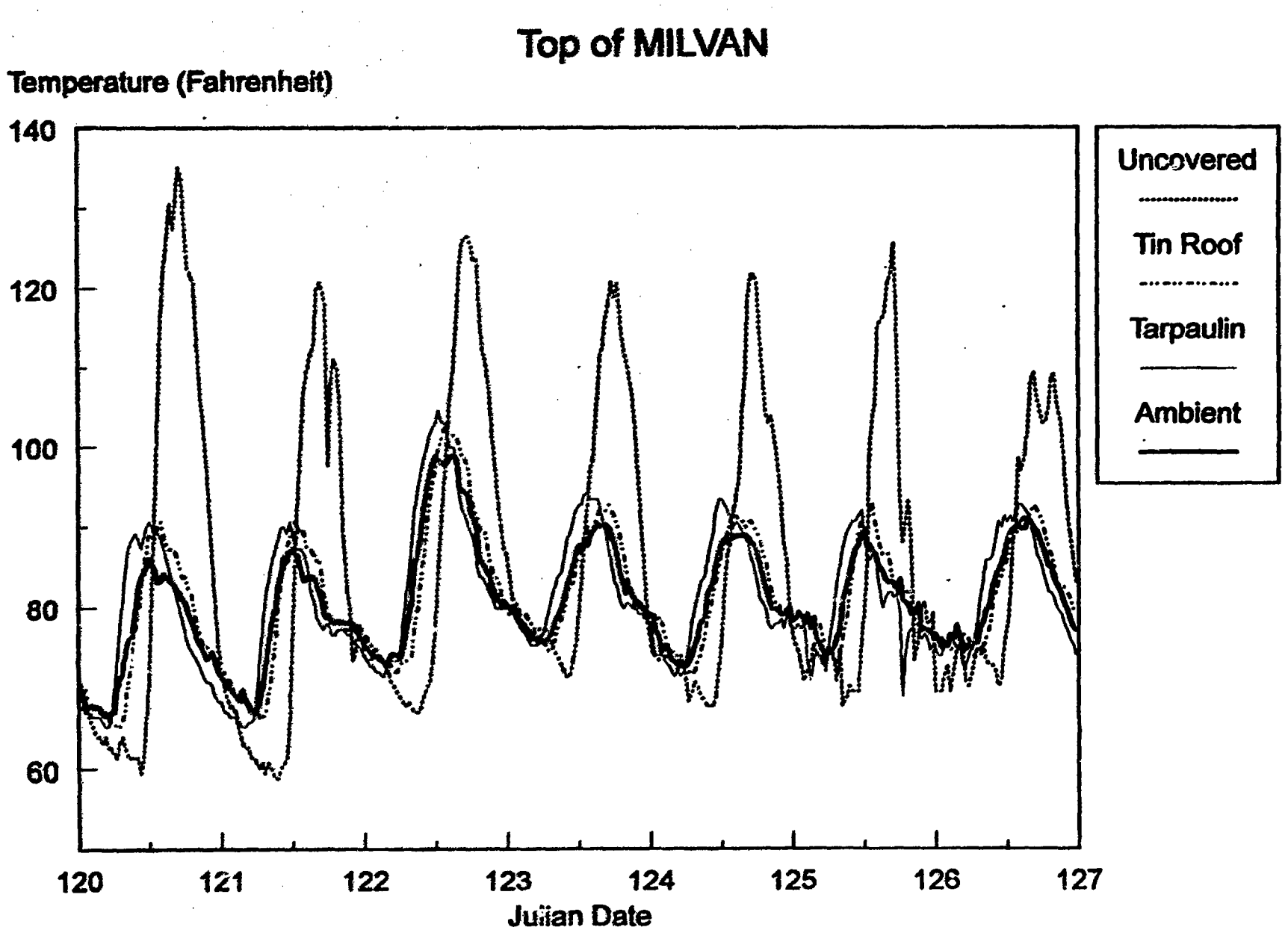
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Tin Roof
Tarpaulin
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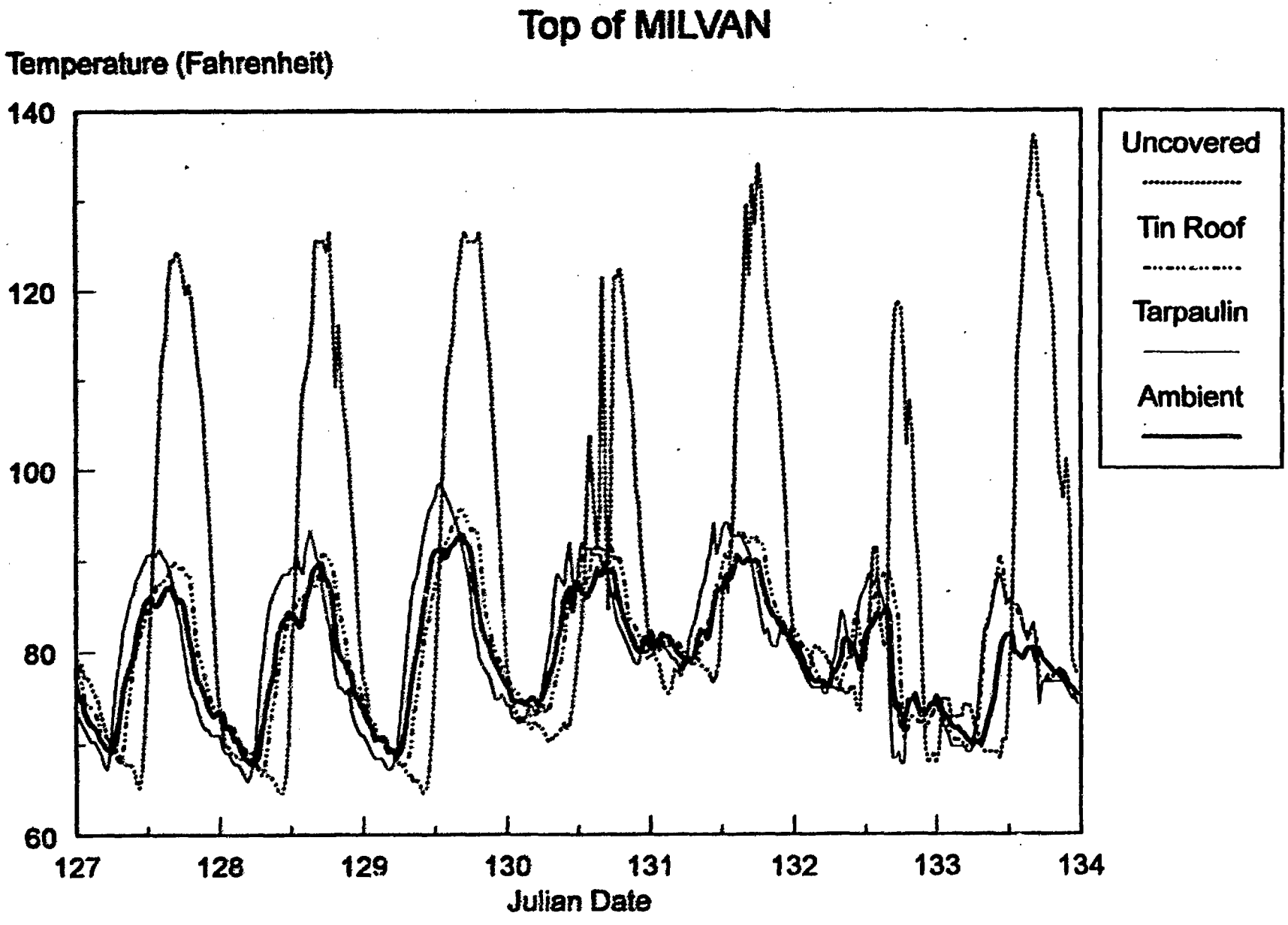
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Julian Date
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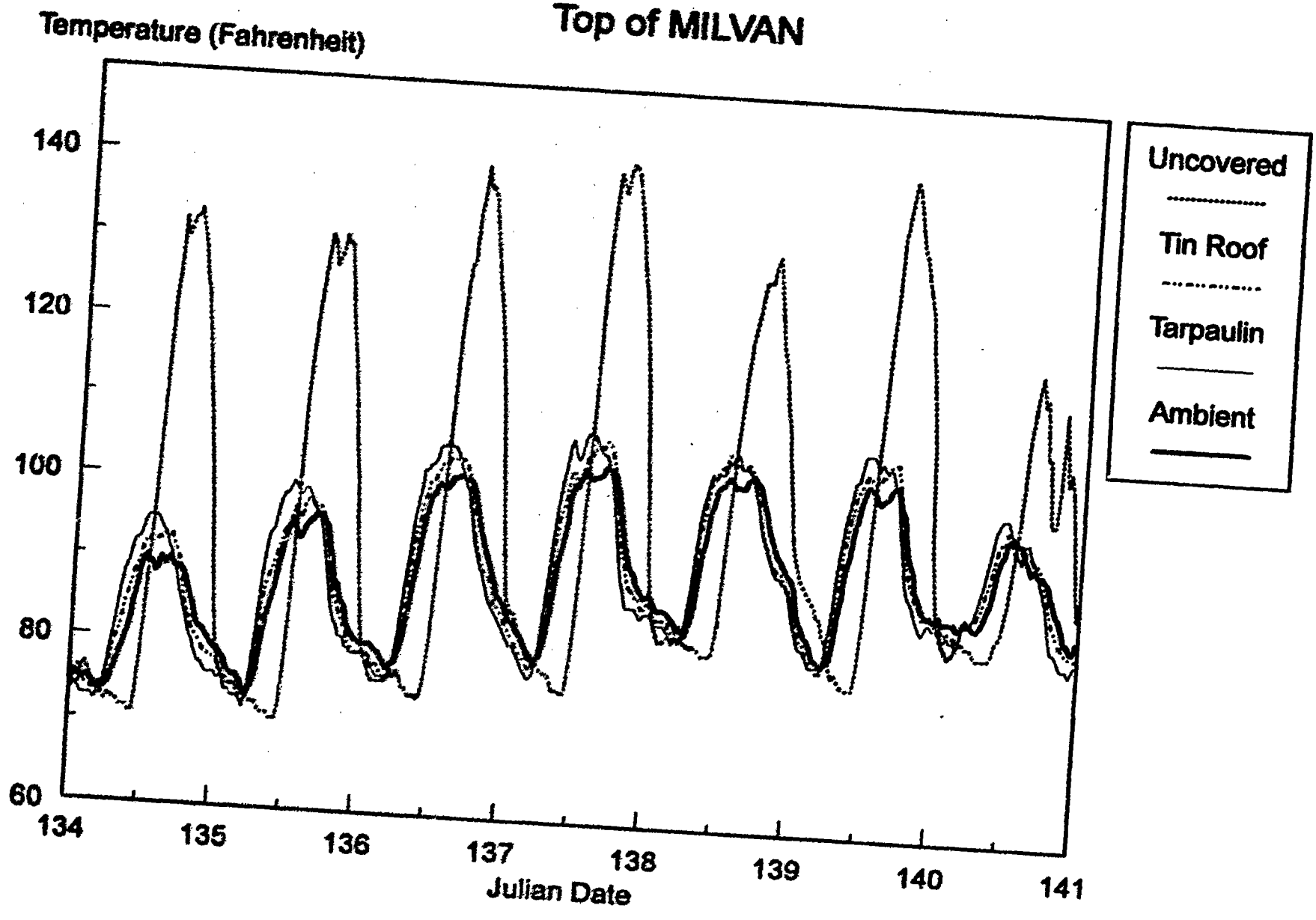
Tarpaulin
Ambient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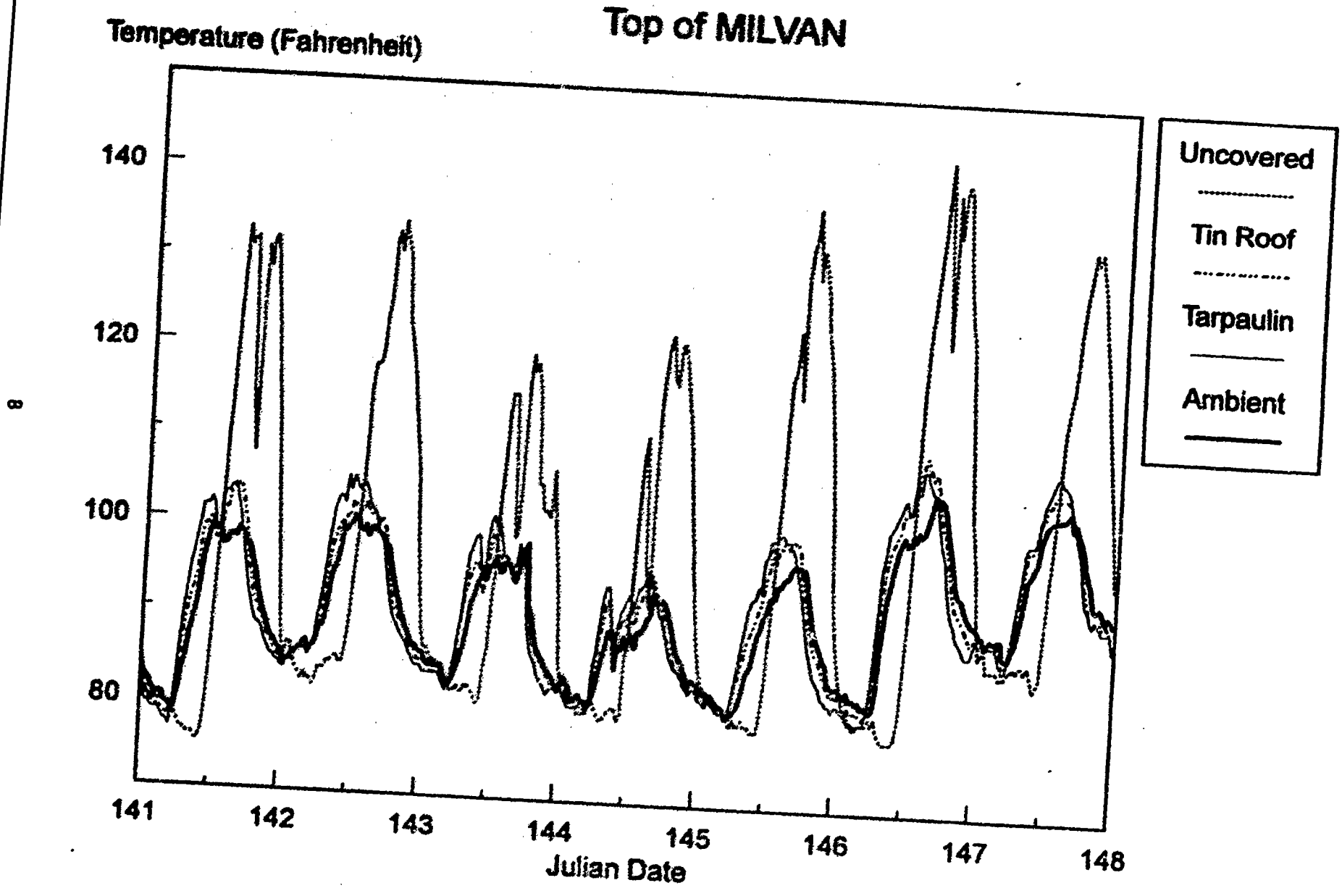
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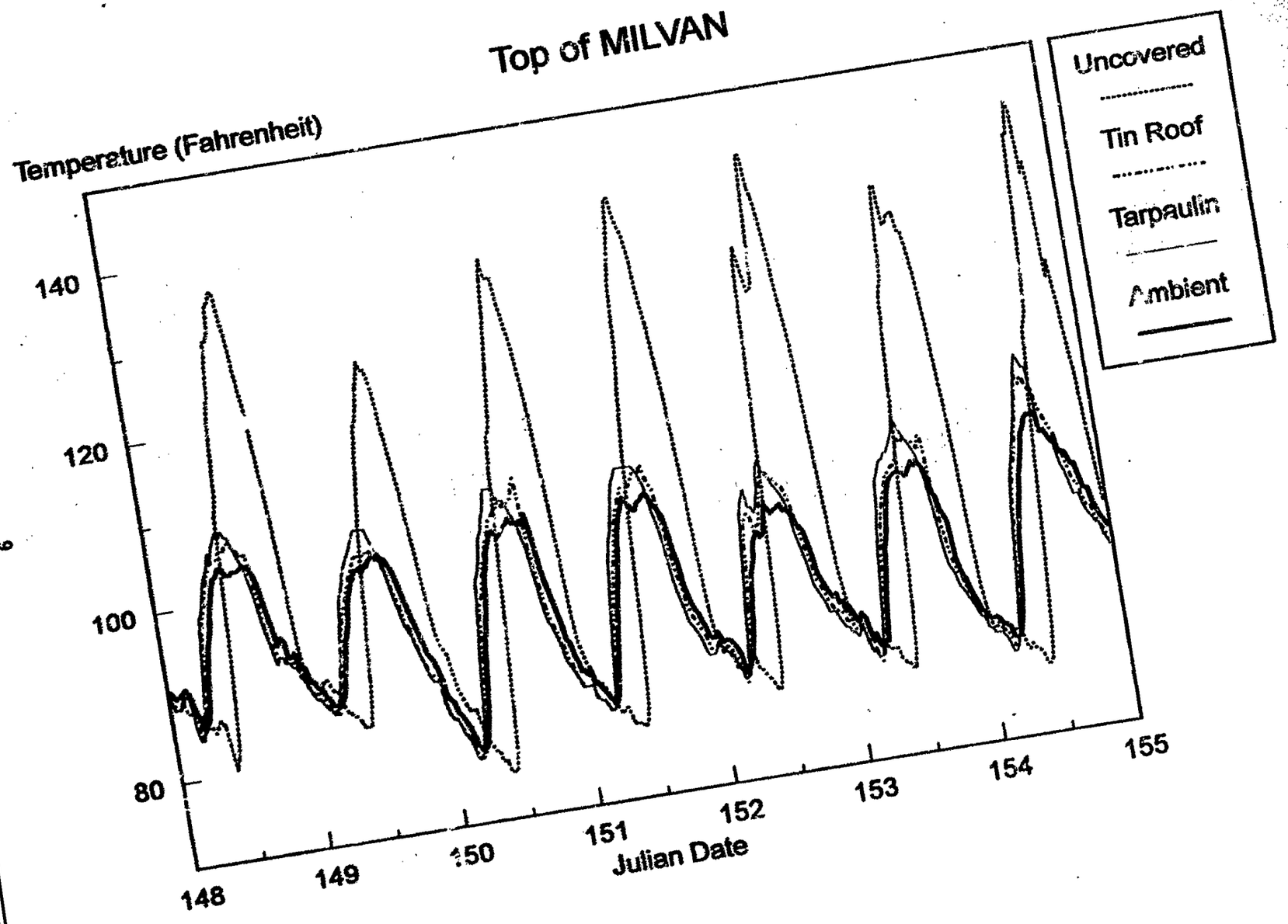
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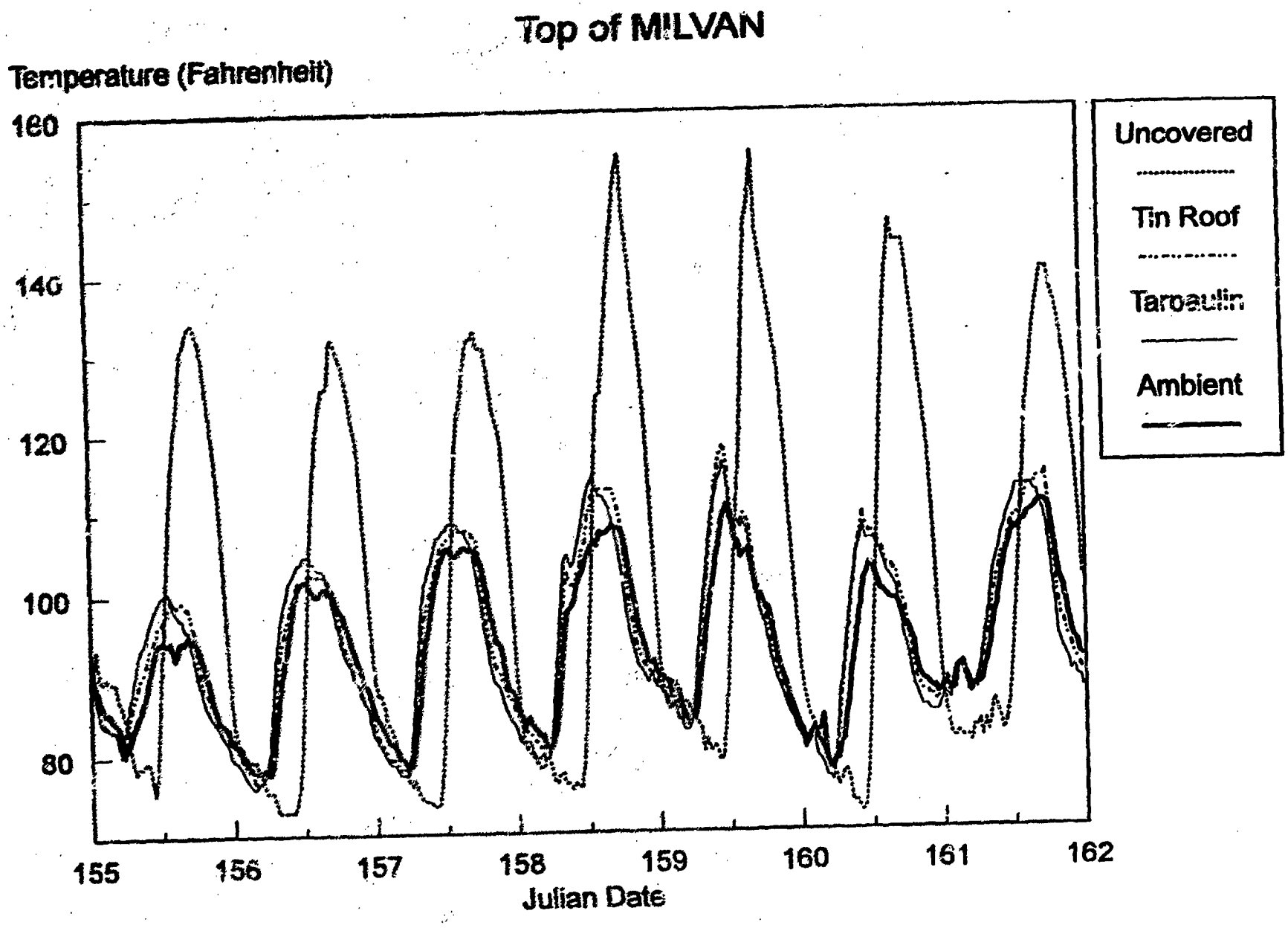
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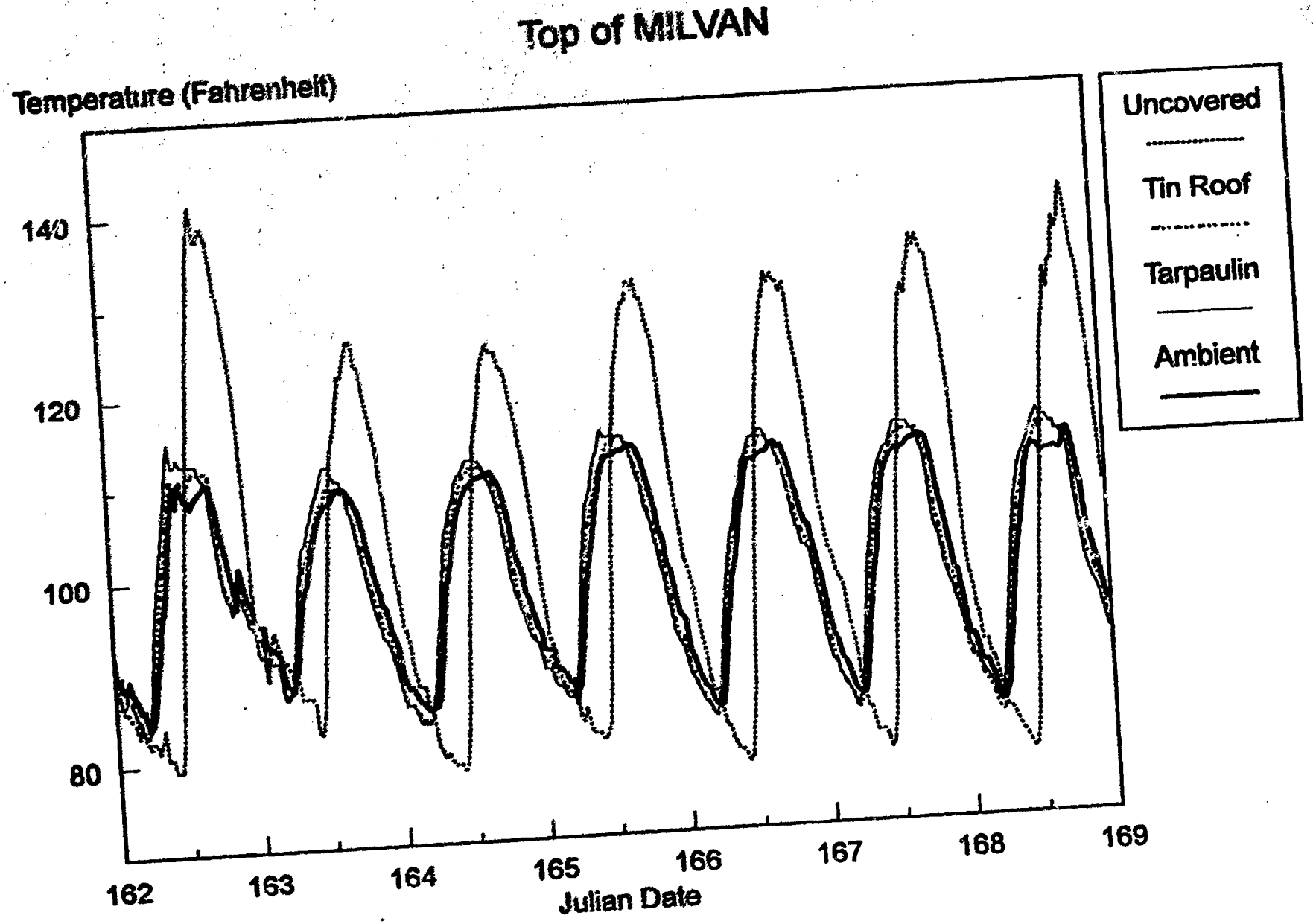
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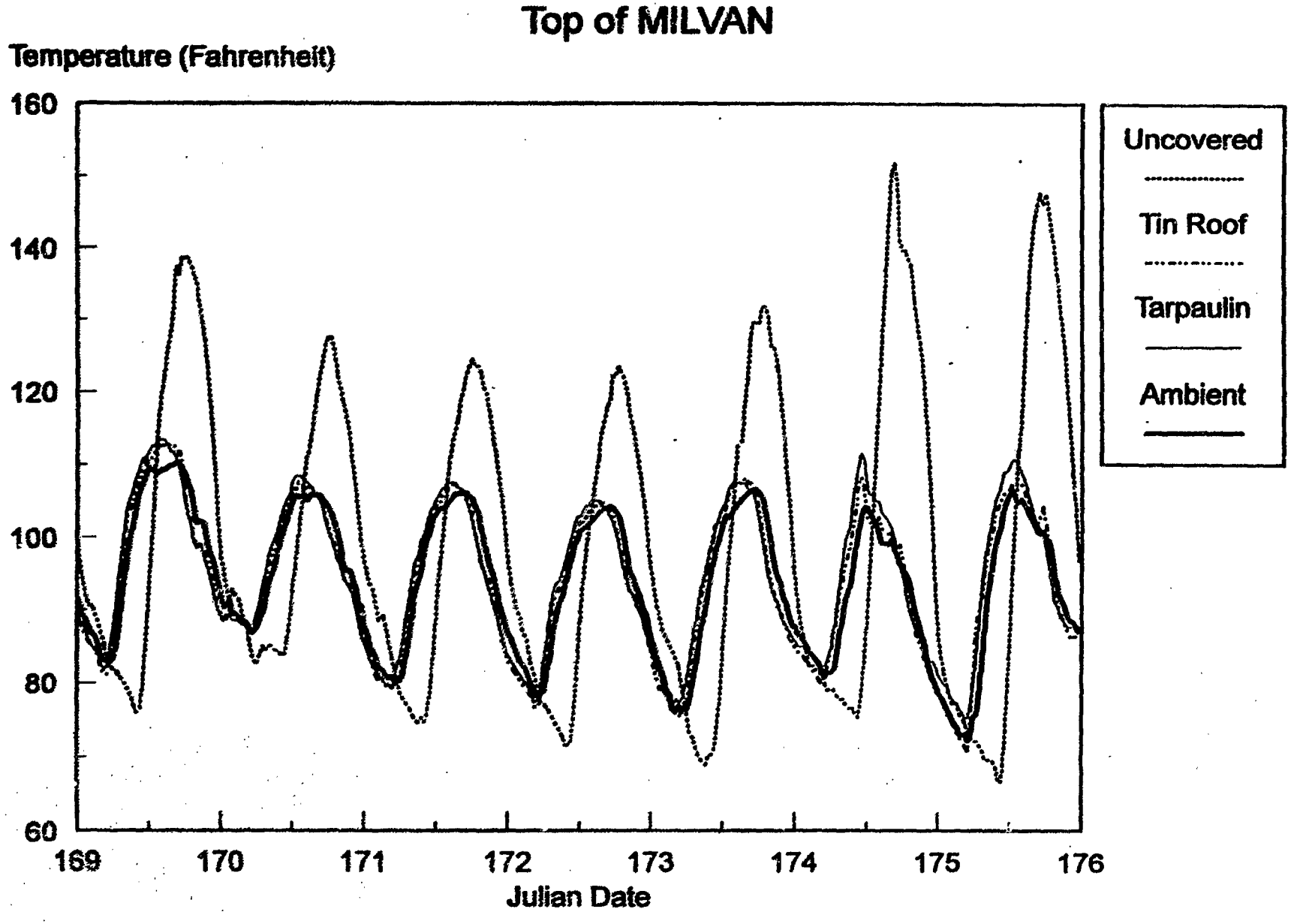
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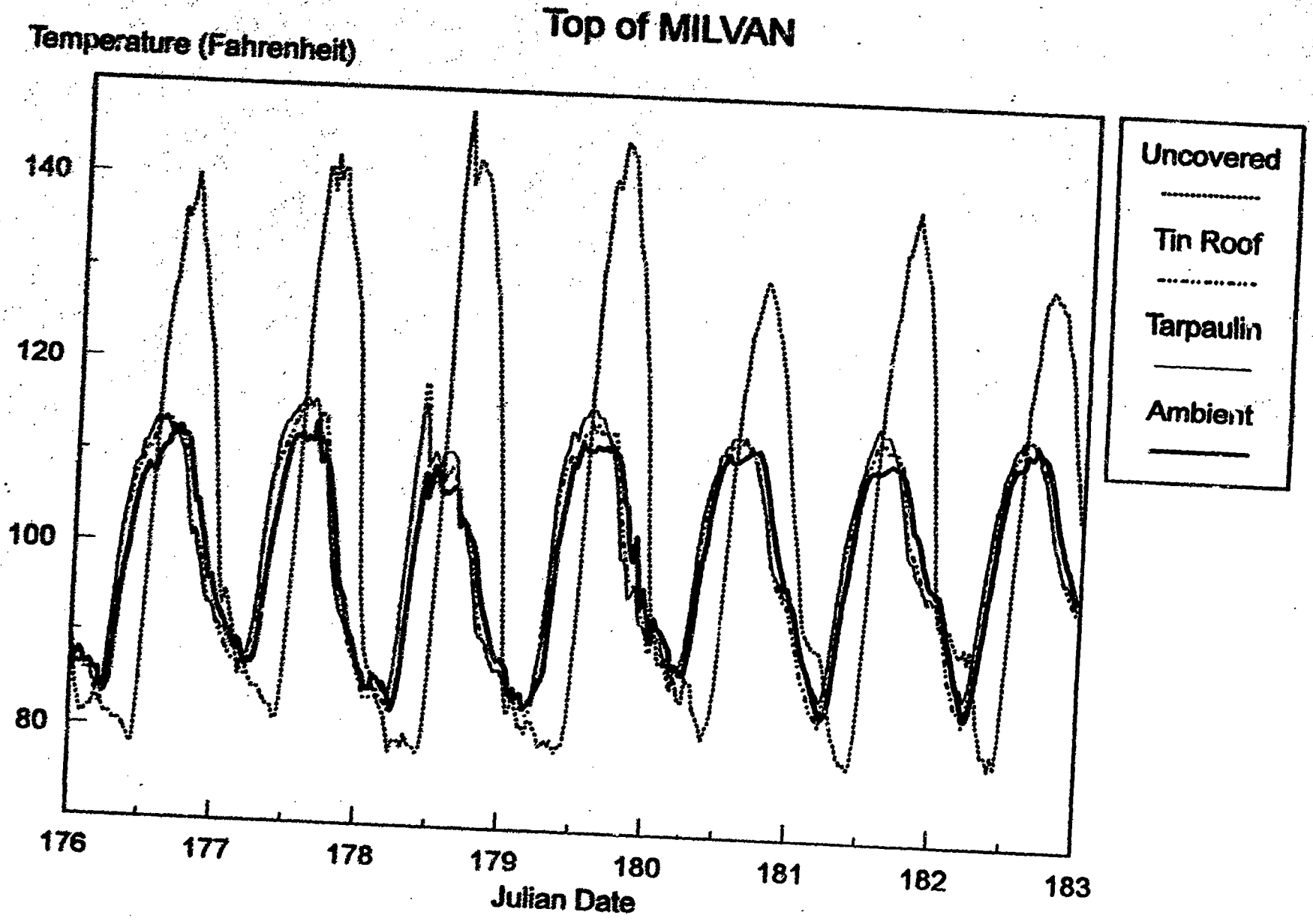
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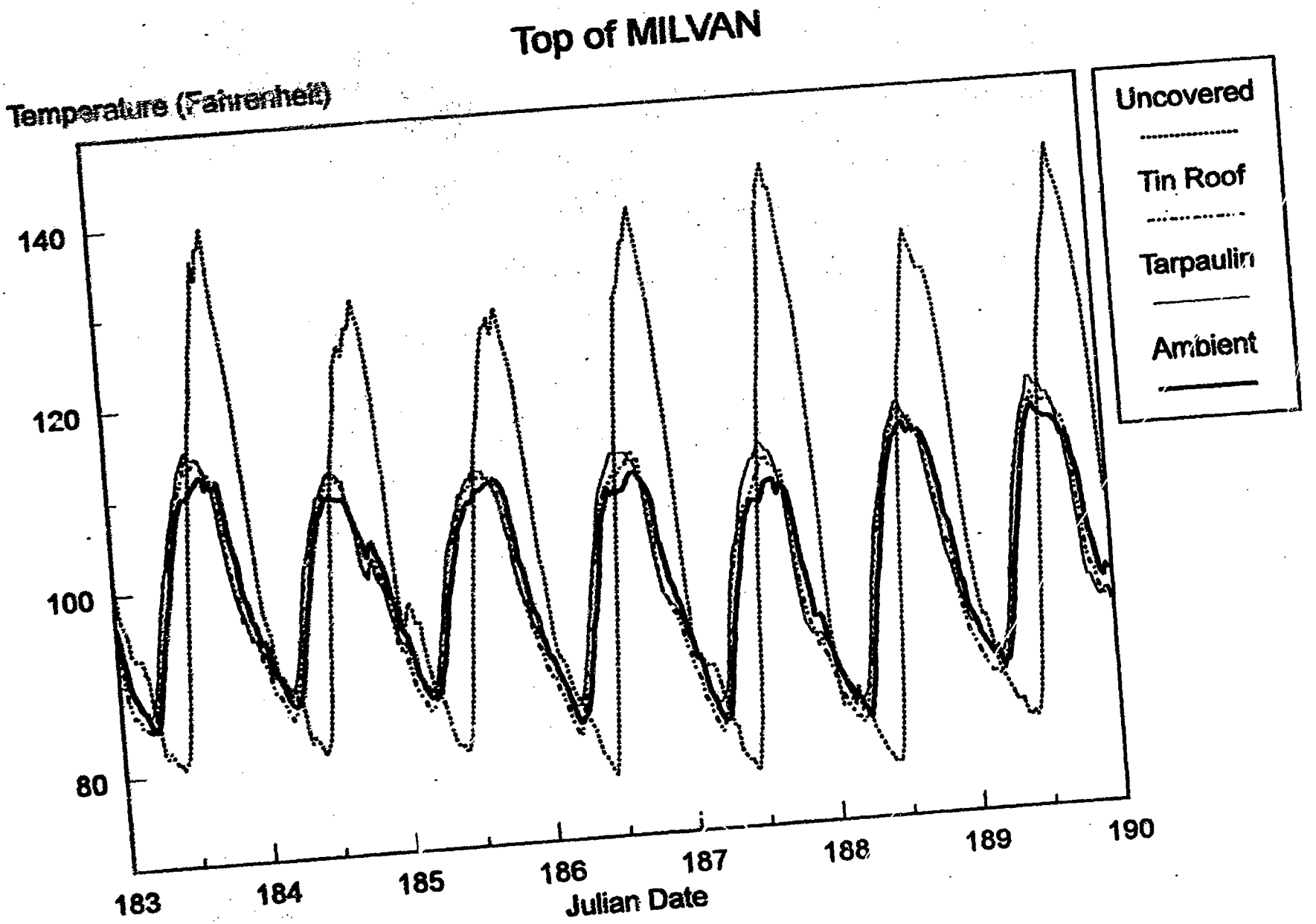
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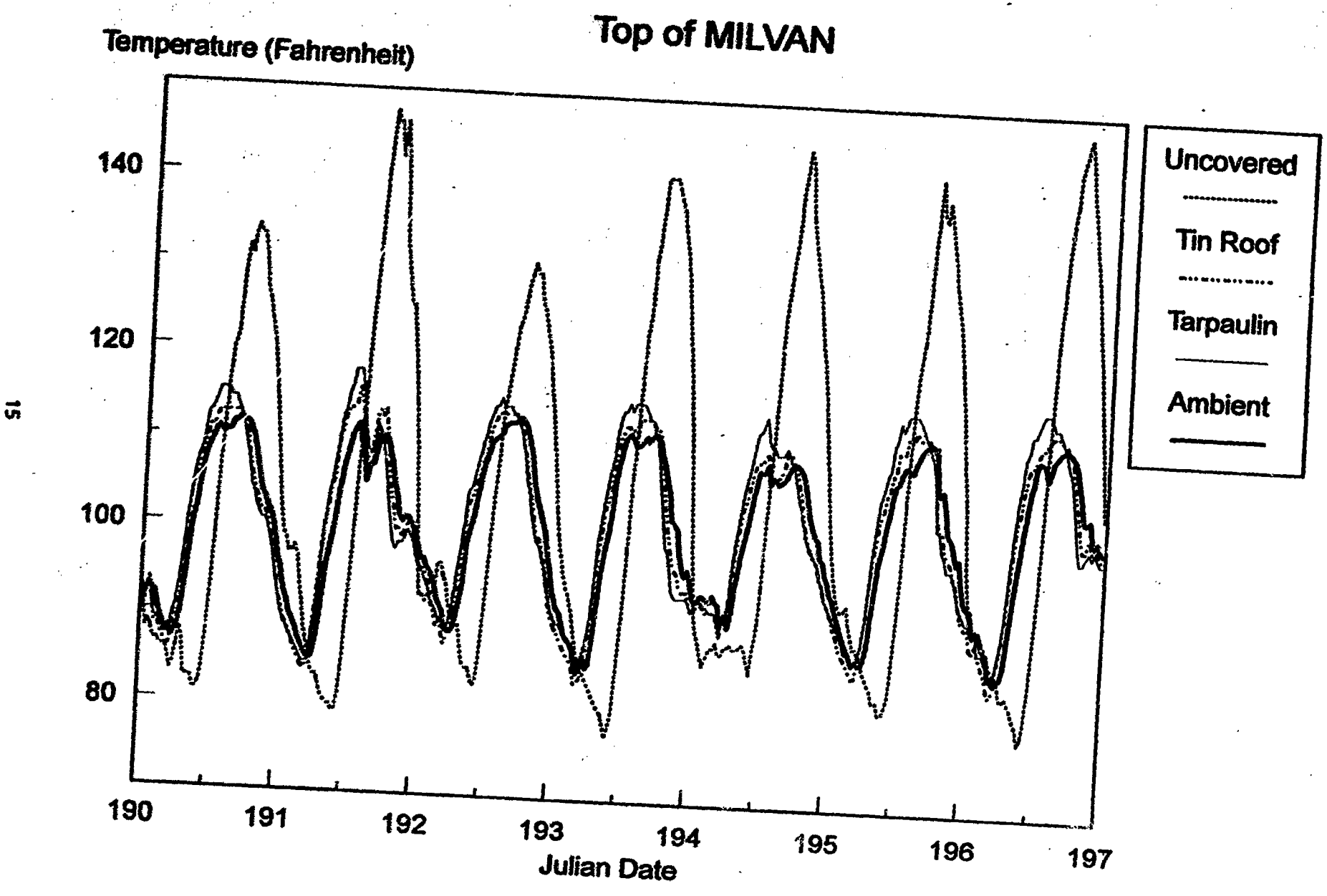
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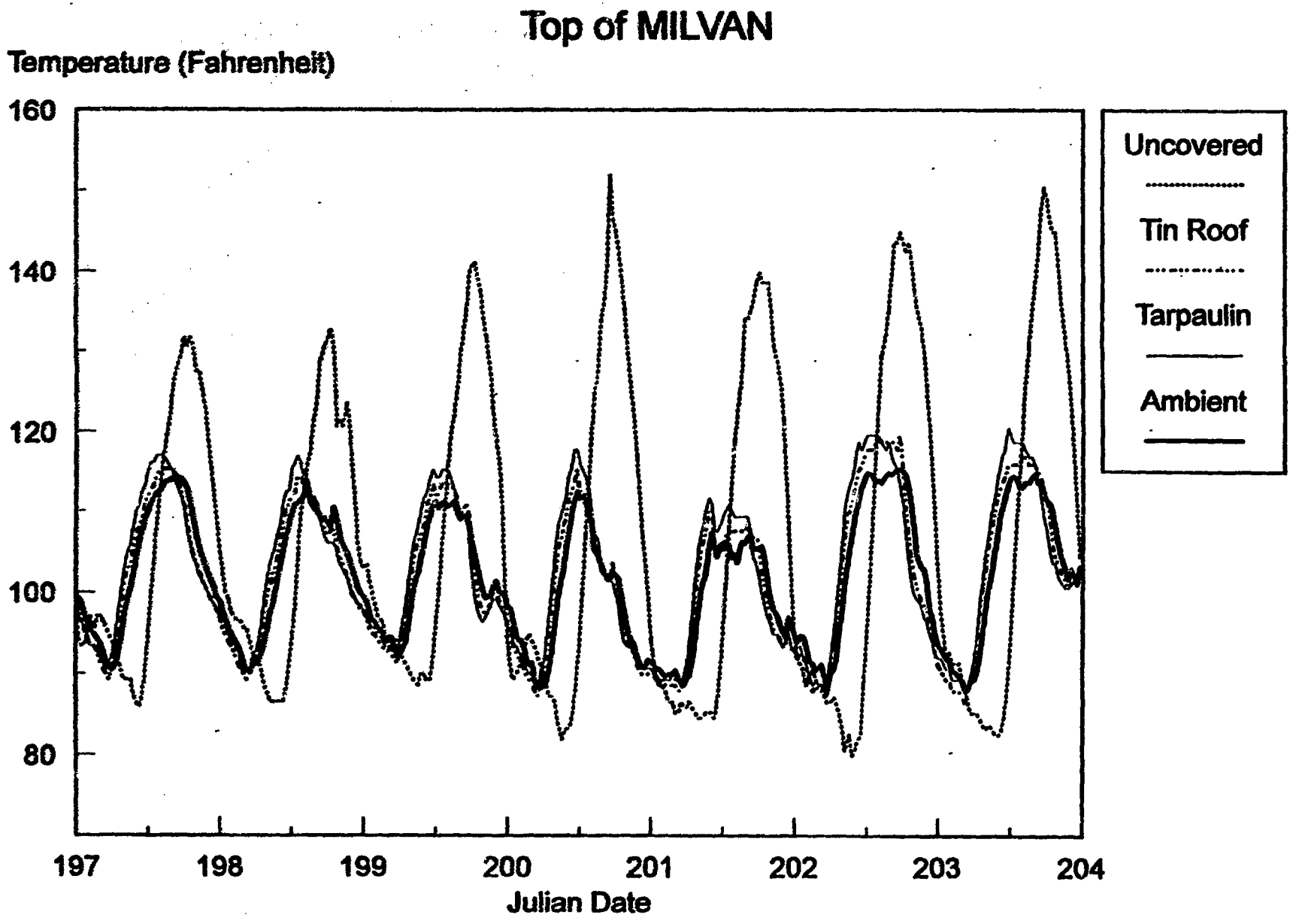
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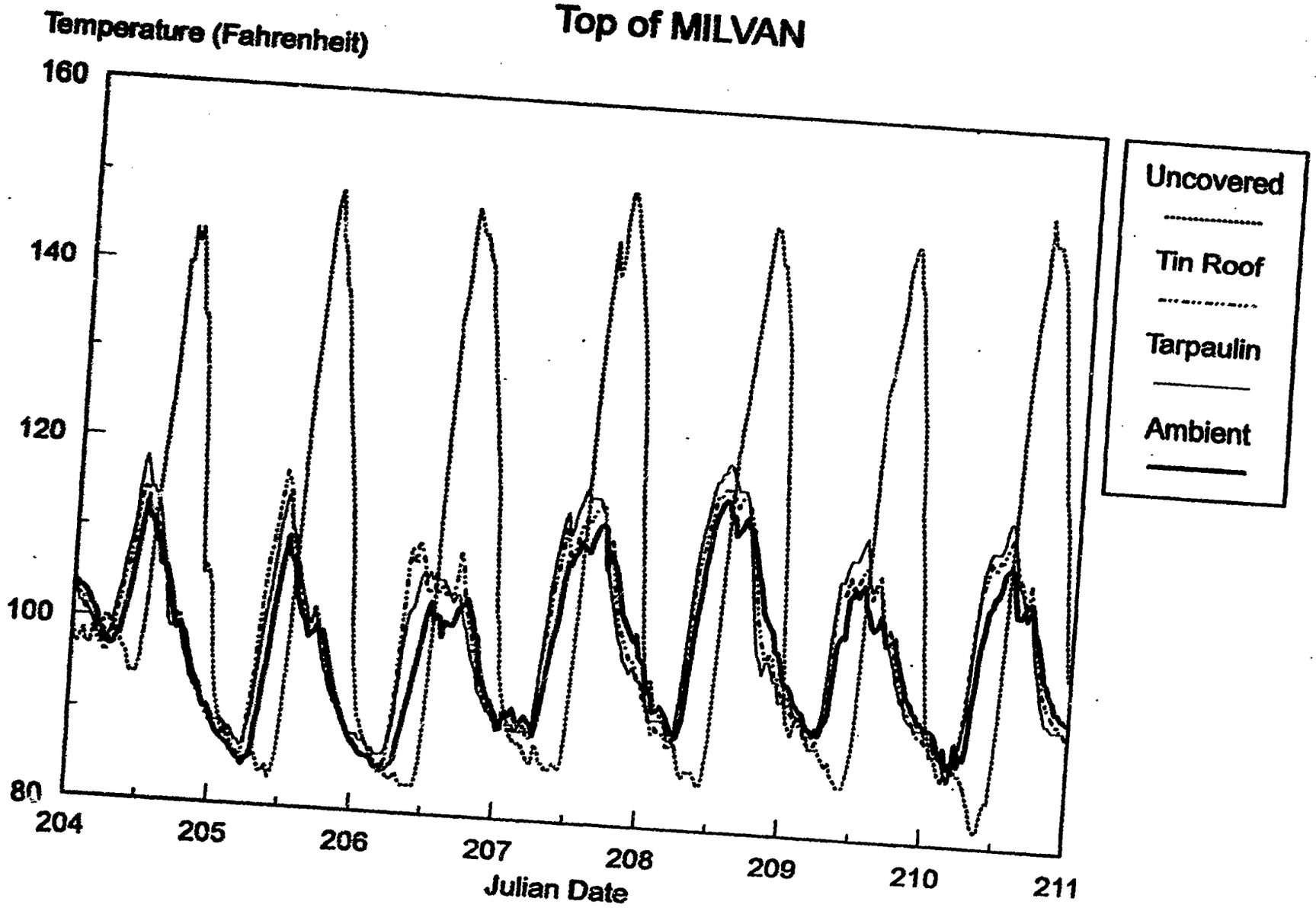
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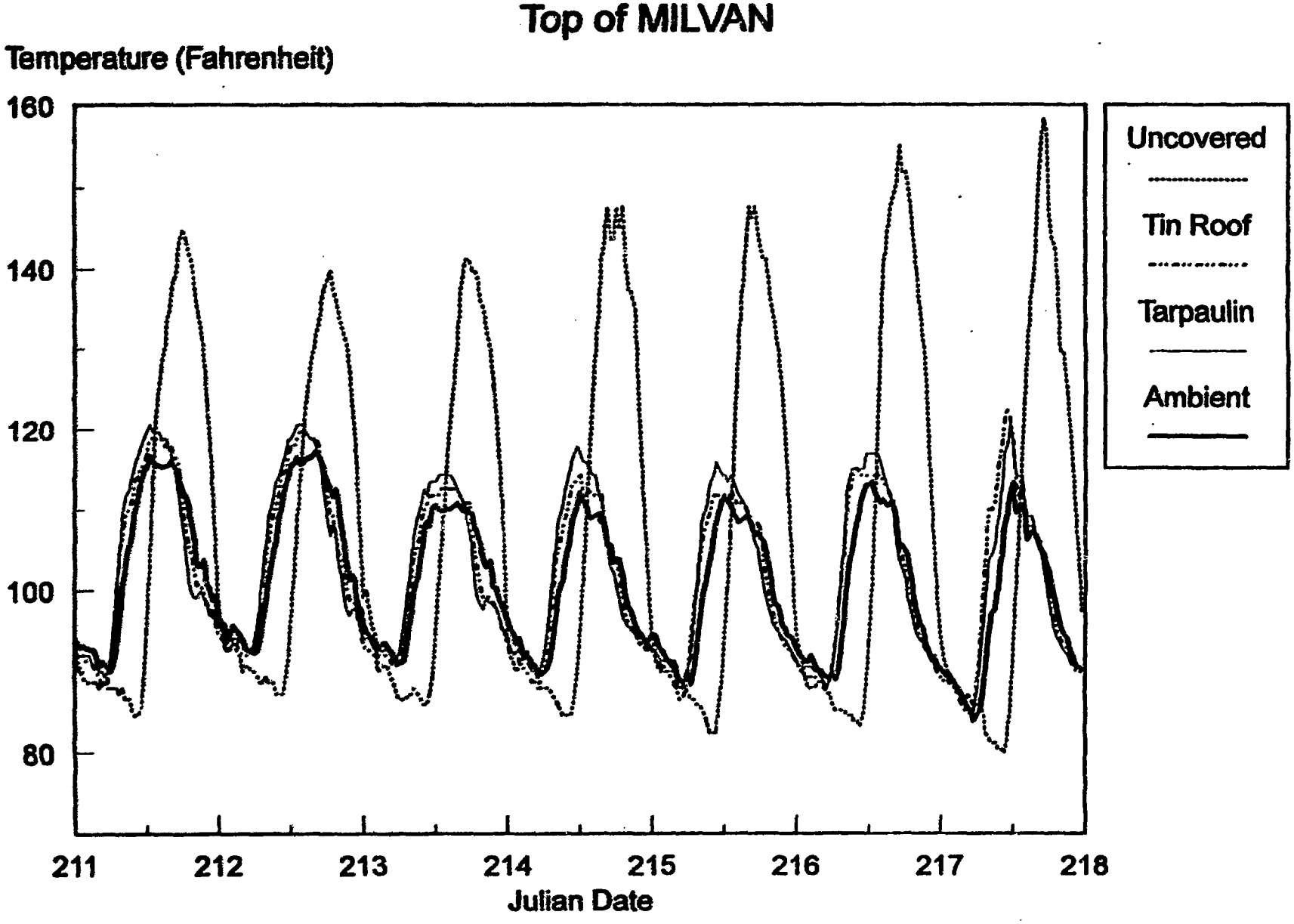
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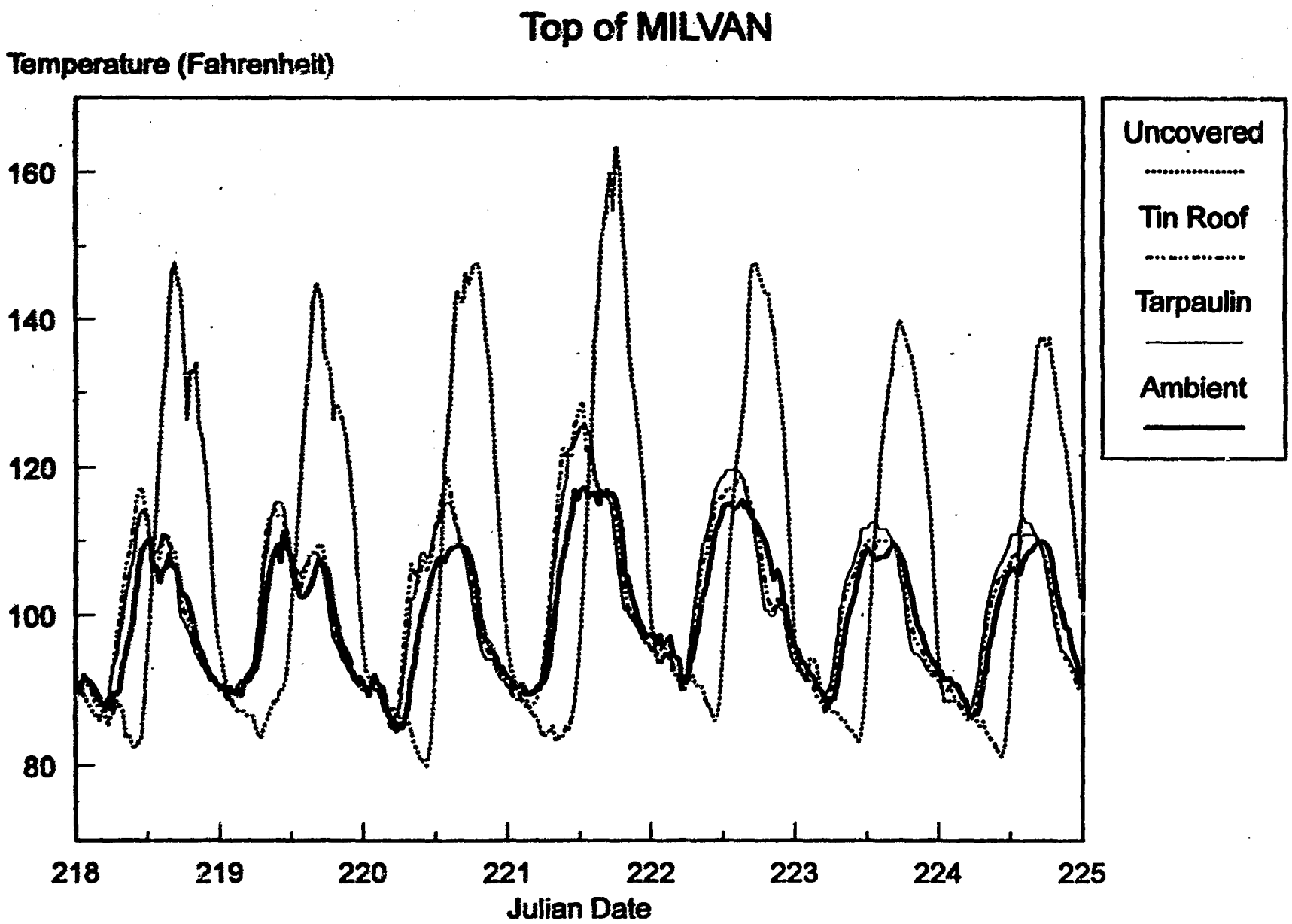
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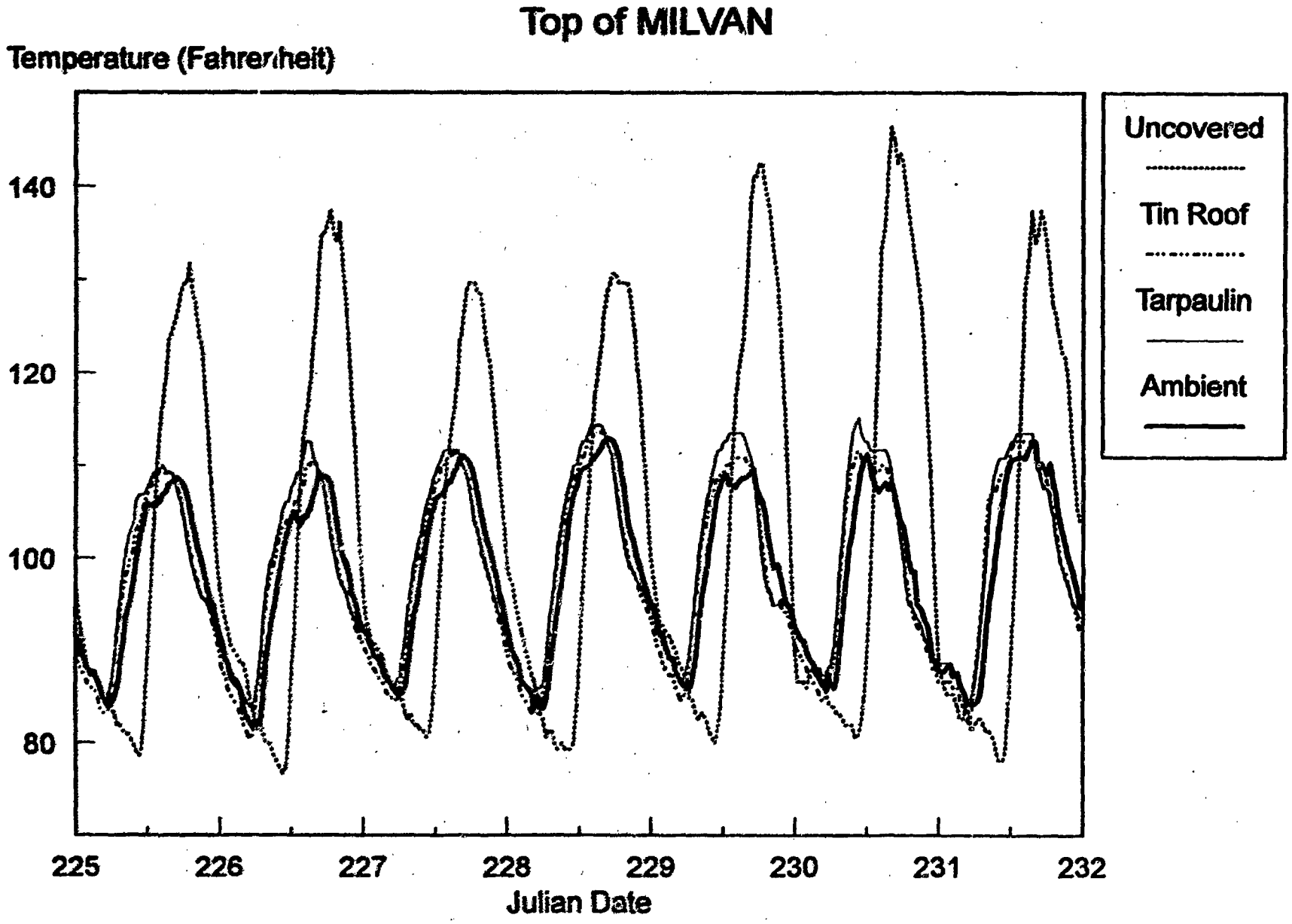
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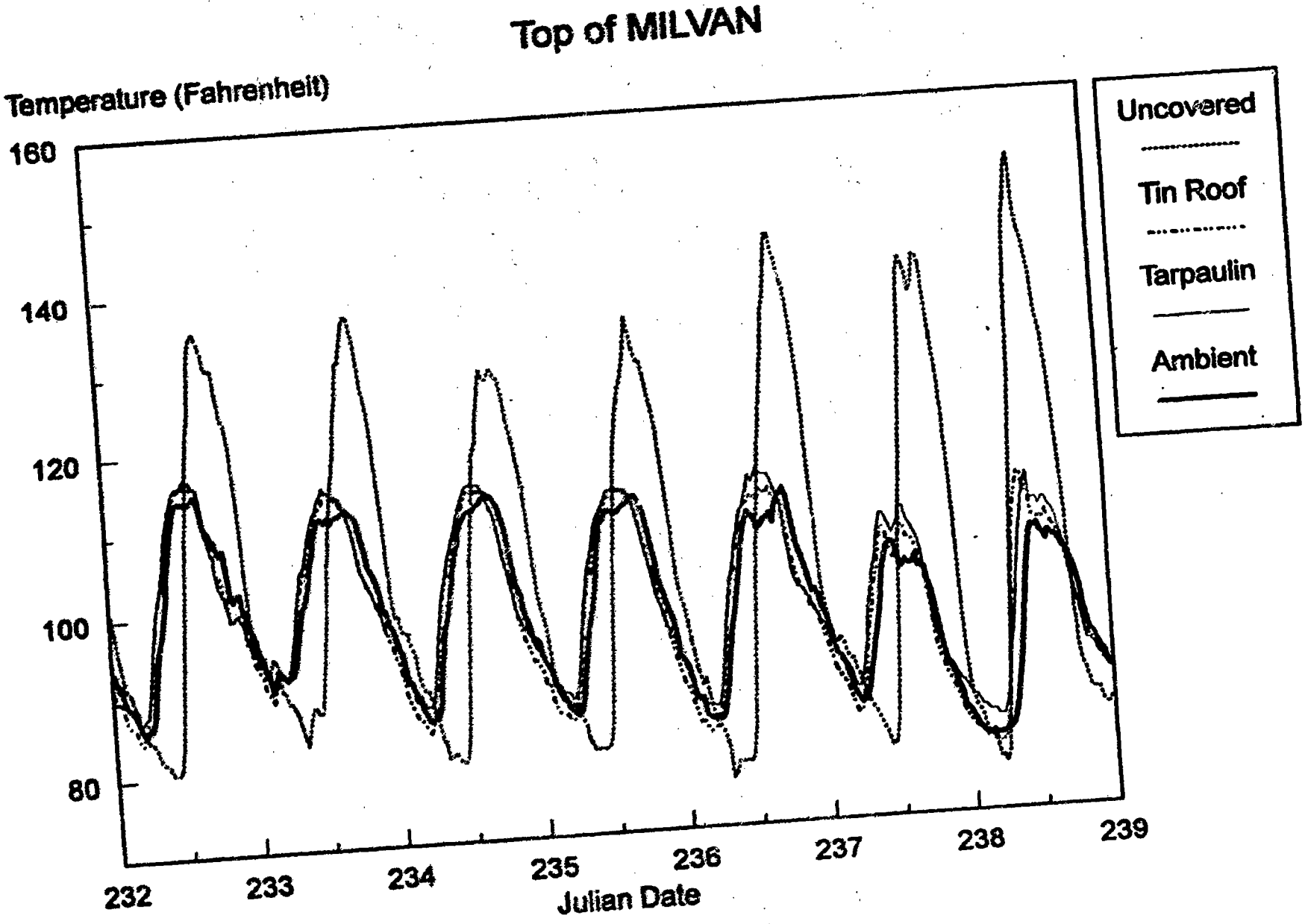
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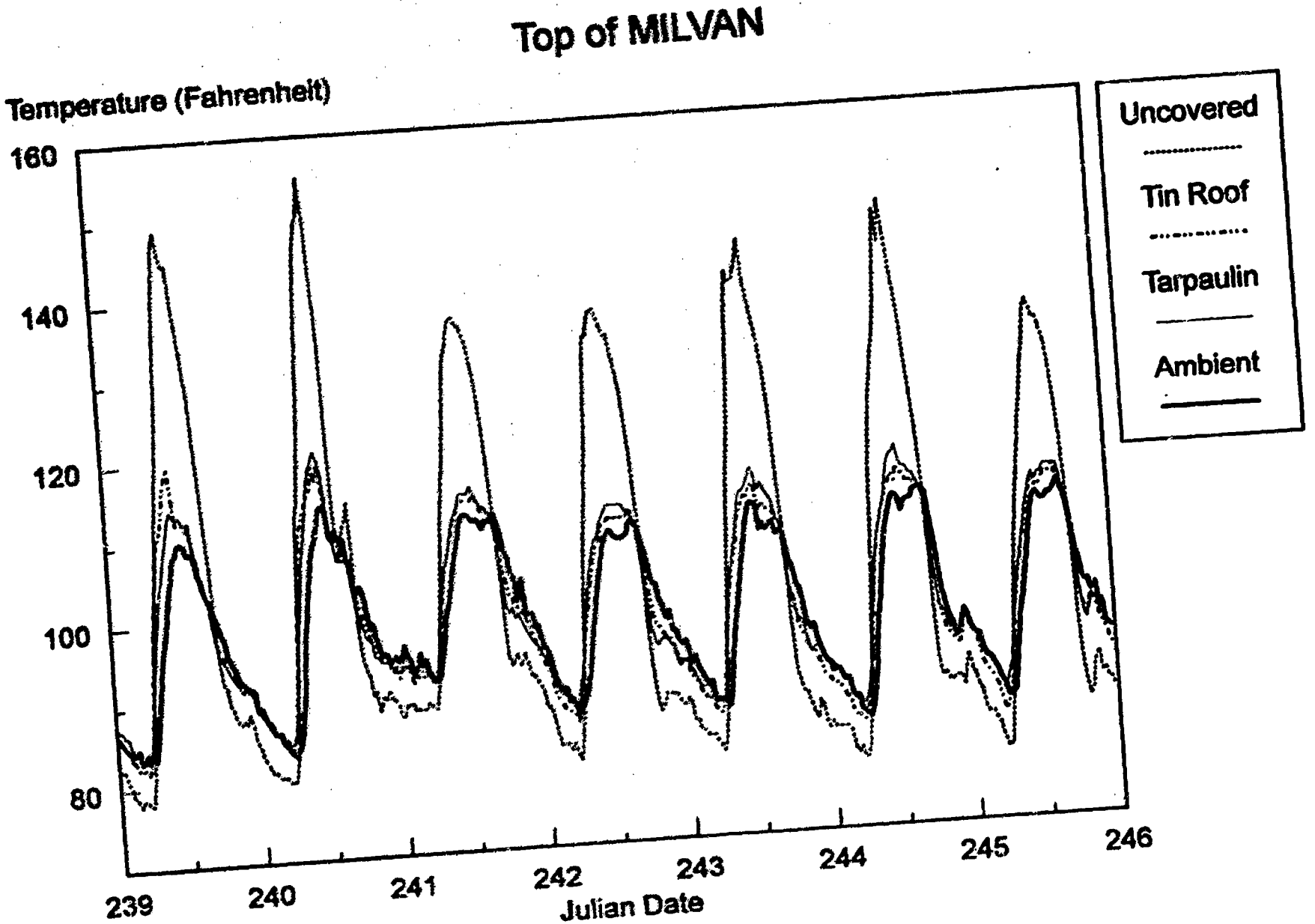
Tarpaulin
Ambient


Top of MILVAN
Temperature (Fahrenheit)
160
140
120
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239
240
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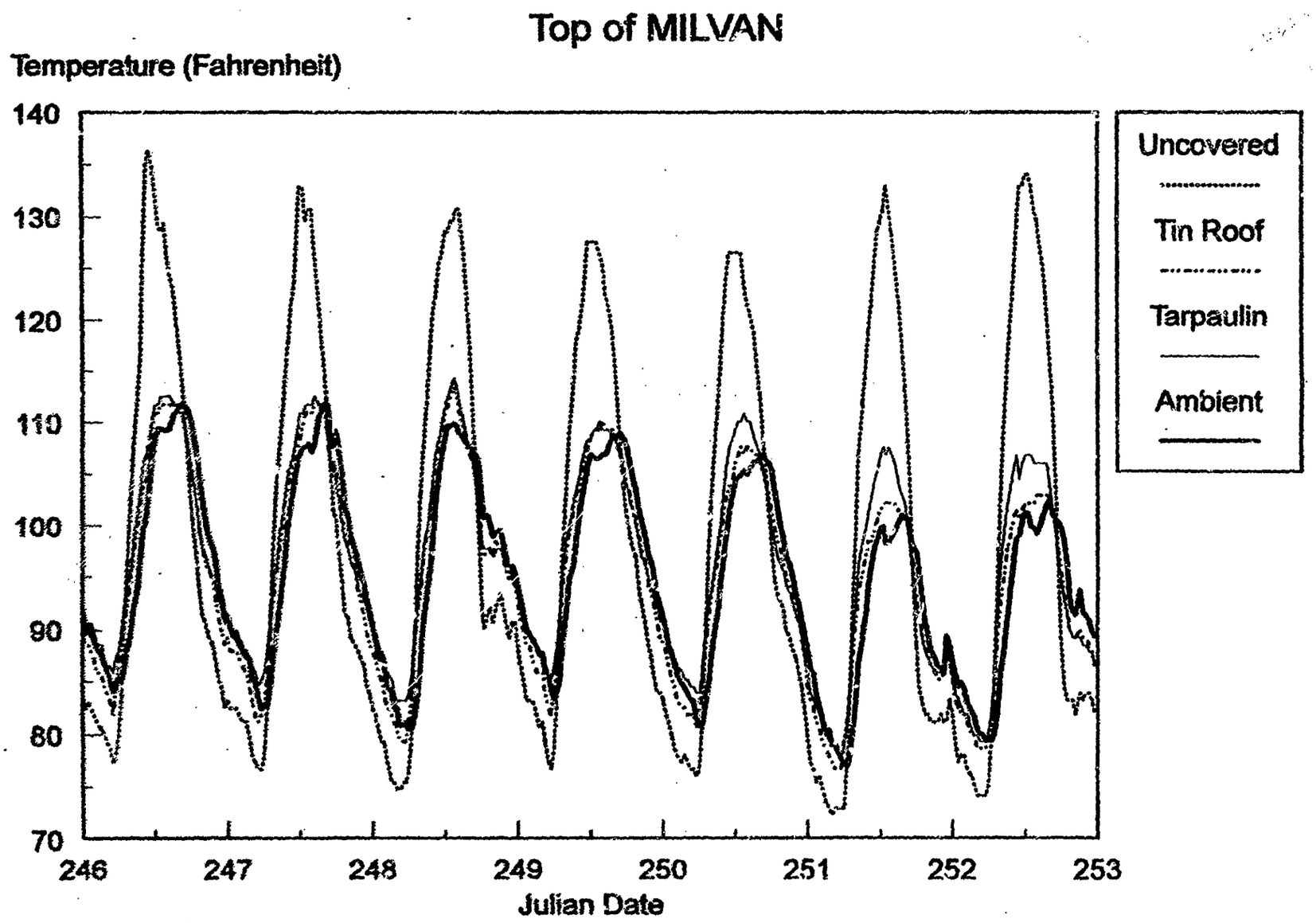
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of MILVAN
Temperature (Fahrenheit)
140
130
120
110
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246
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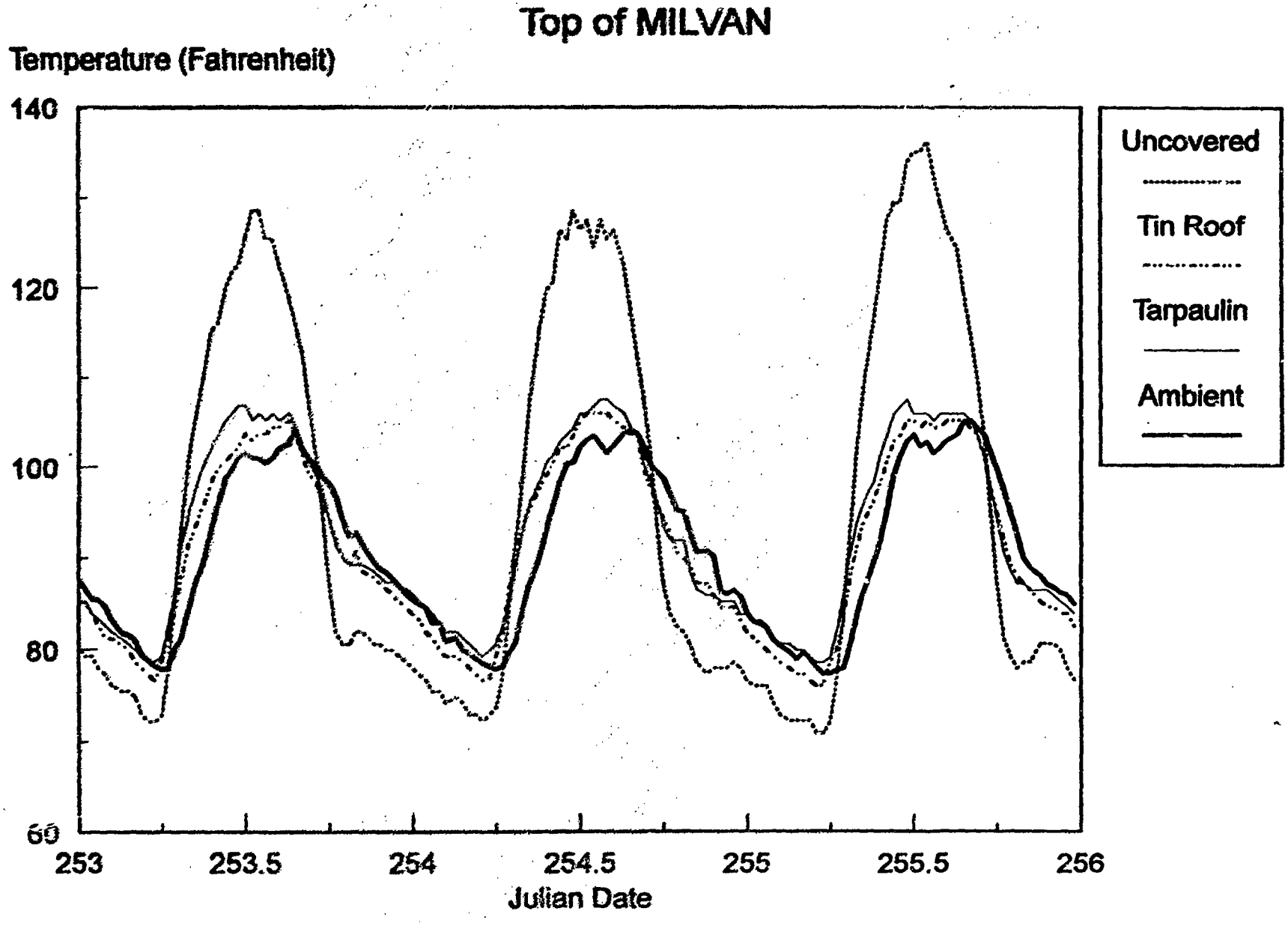
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of MILVAN
Temperature (Fahrenheit)
140
120
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253
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255.5
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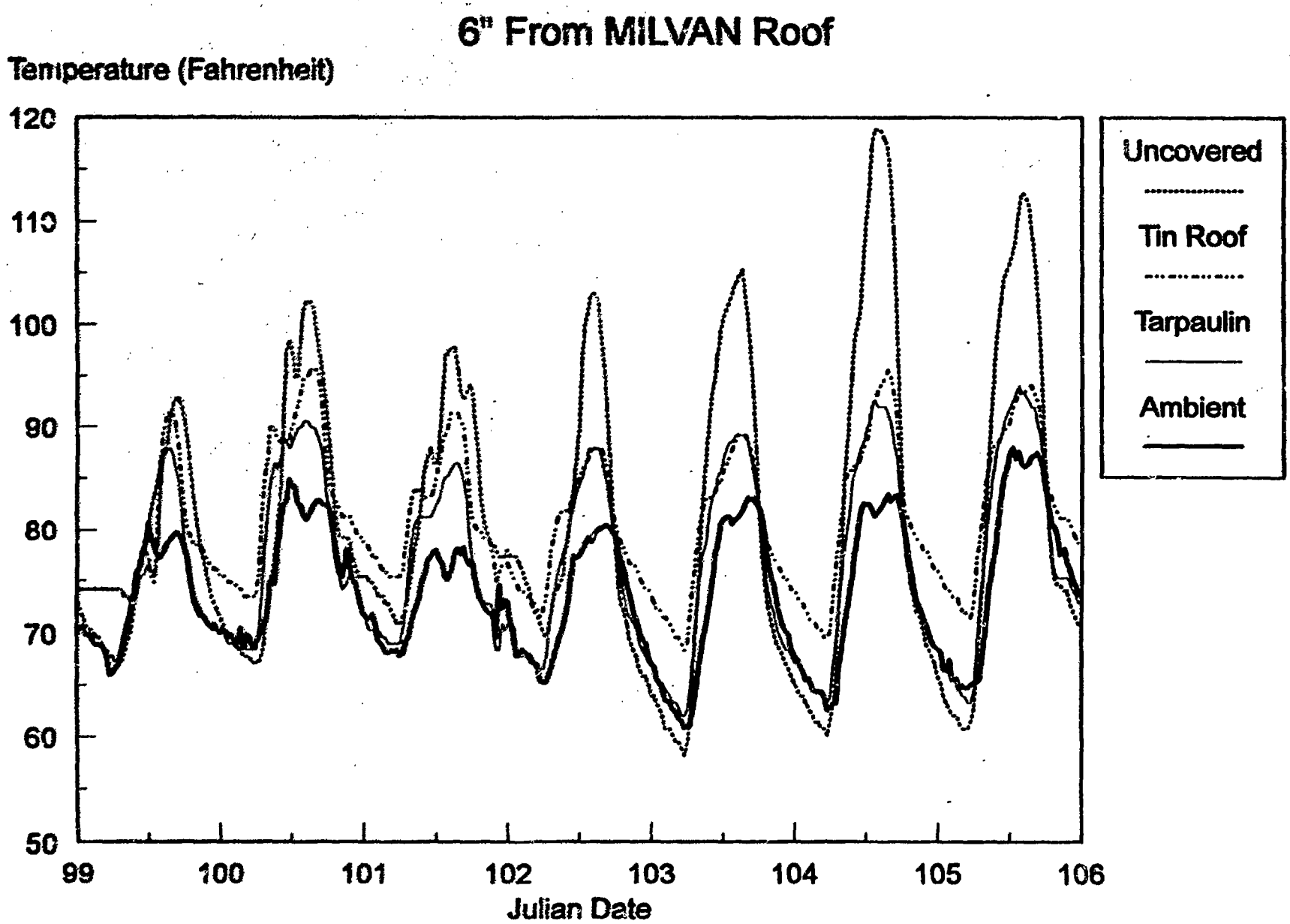
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
120
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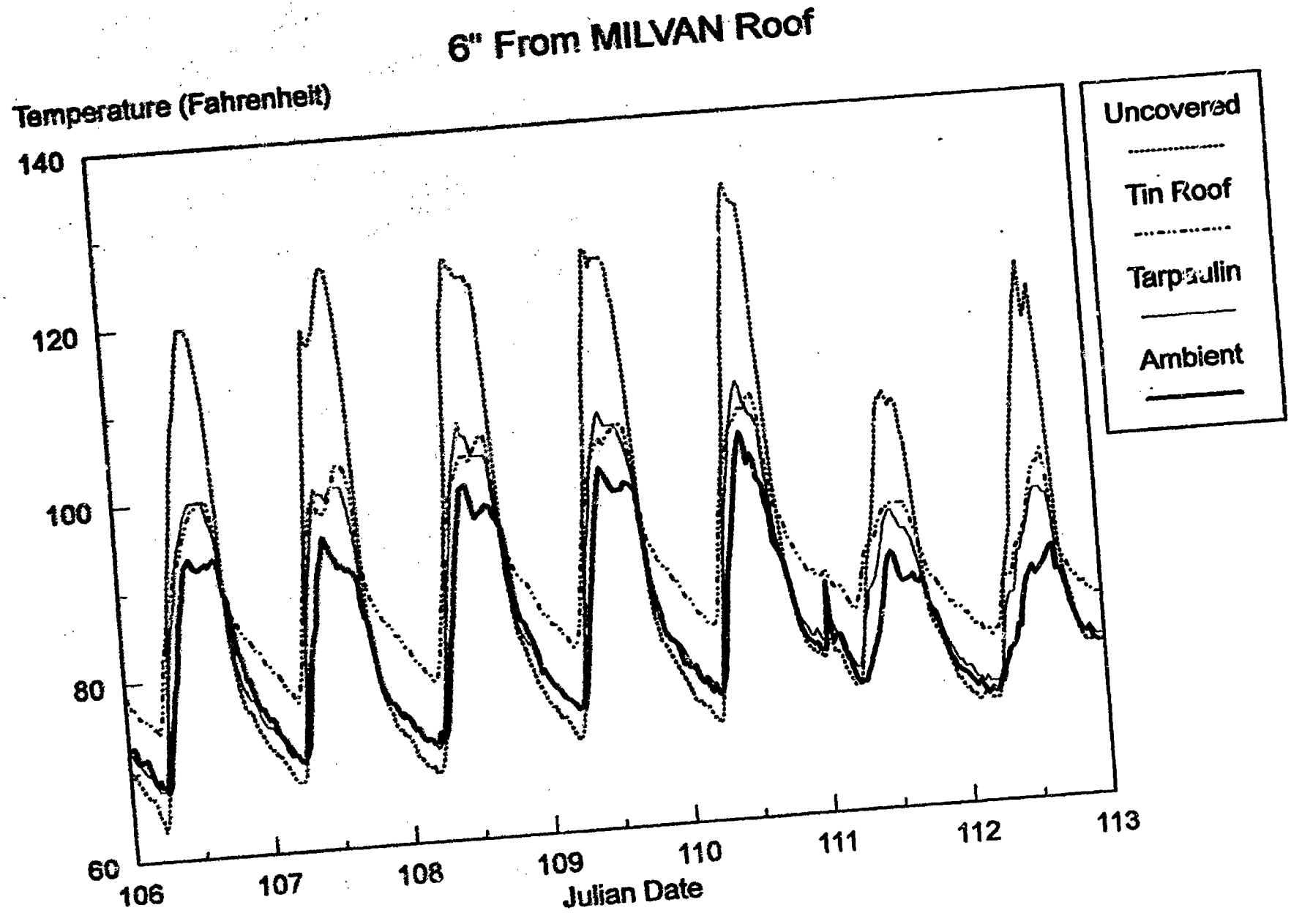
105
106
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
140
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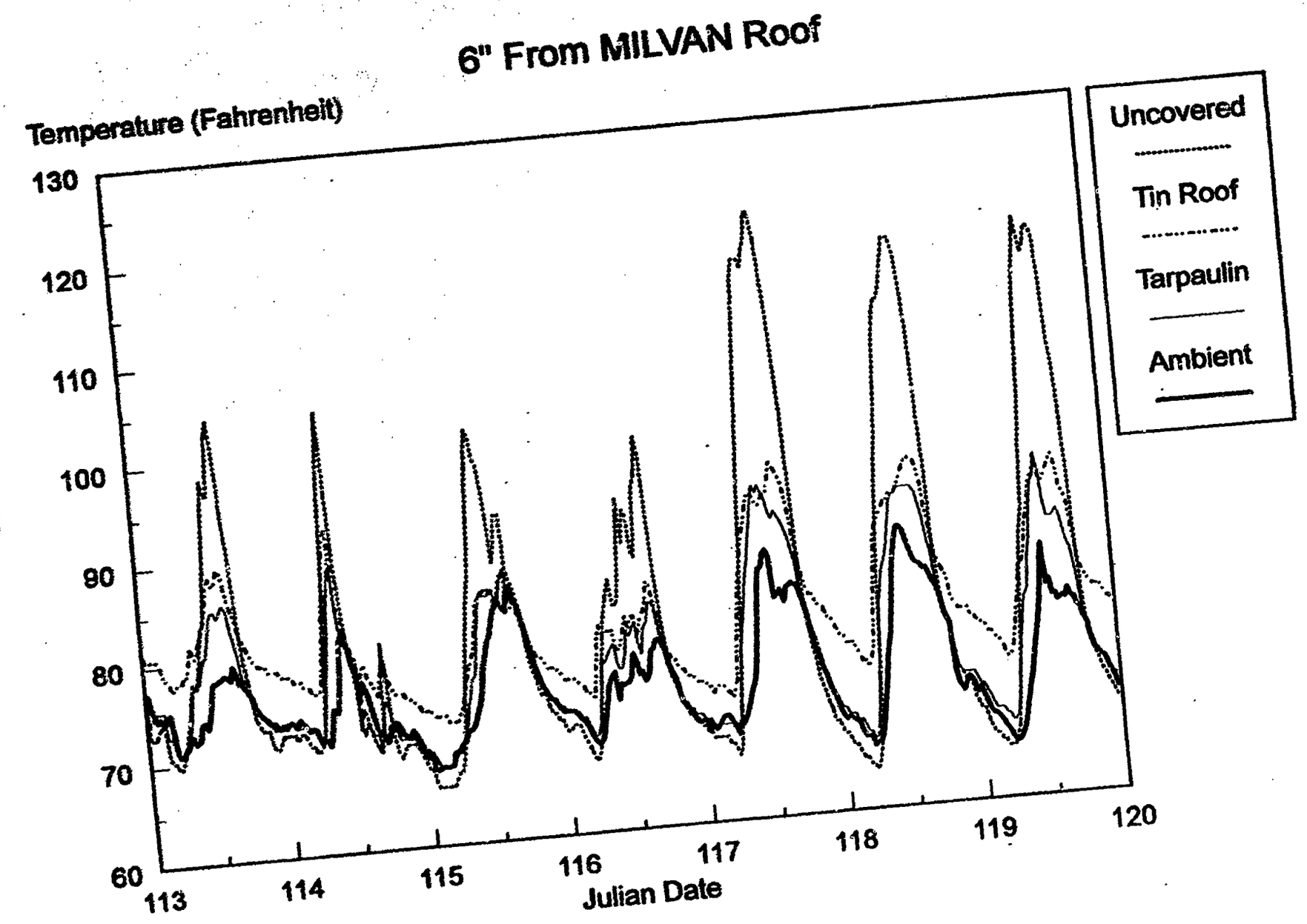
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
130
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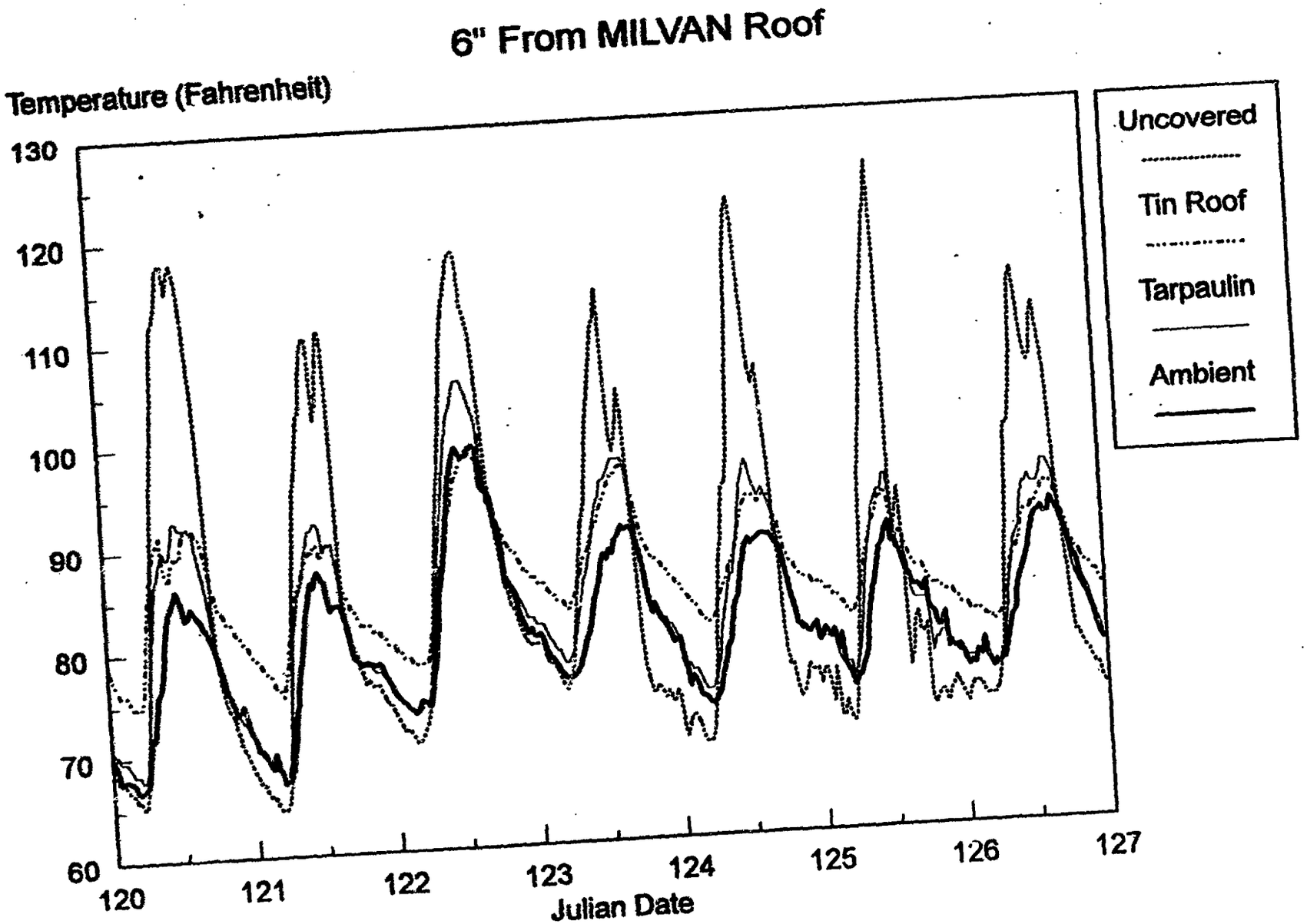
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
130
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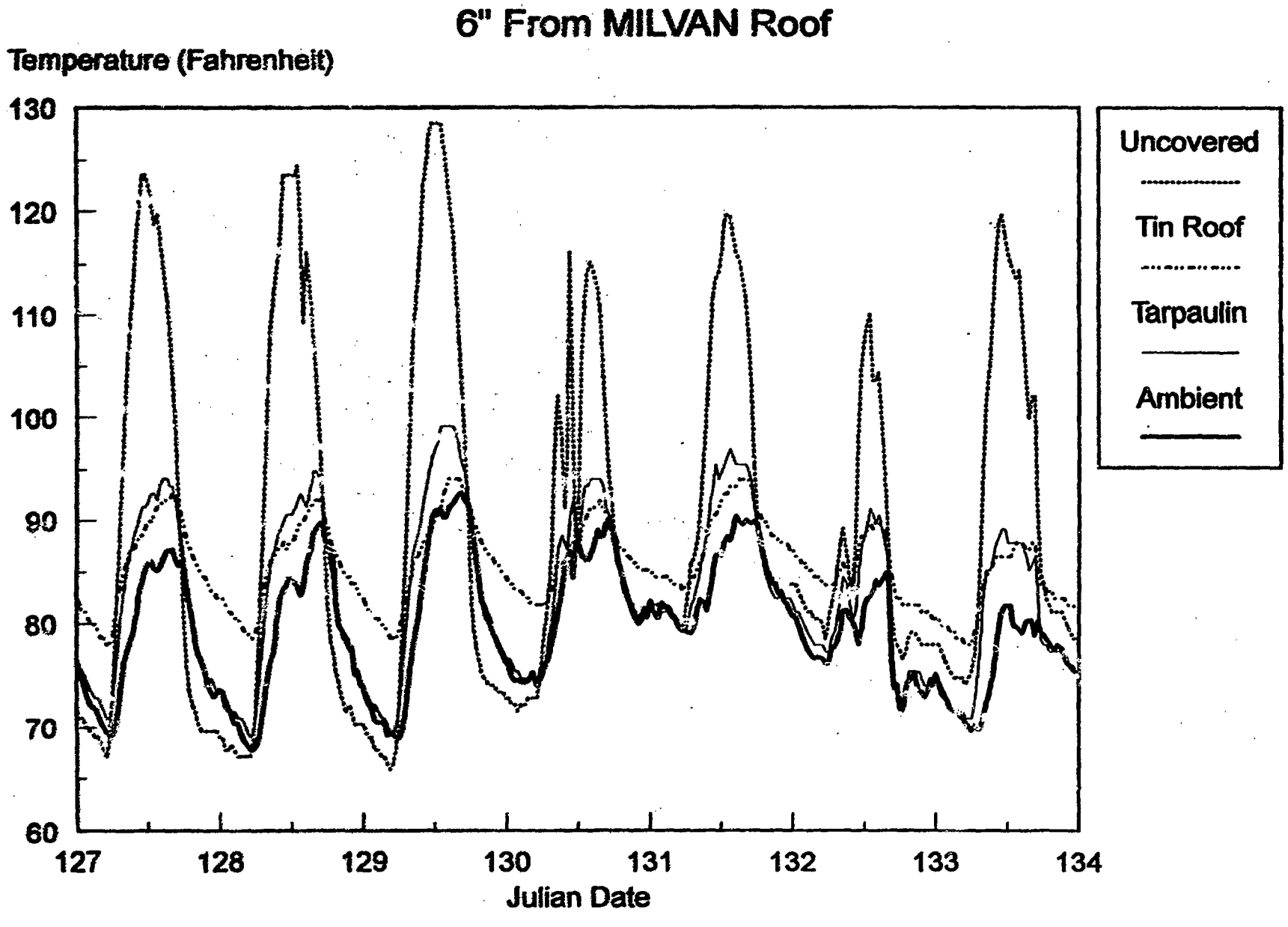
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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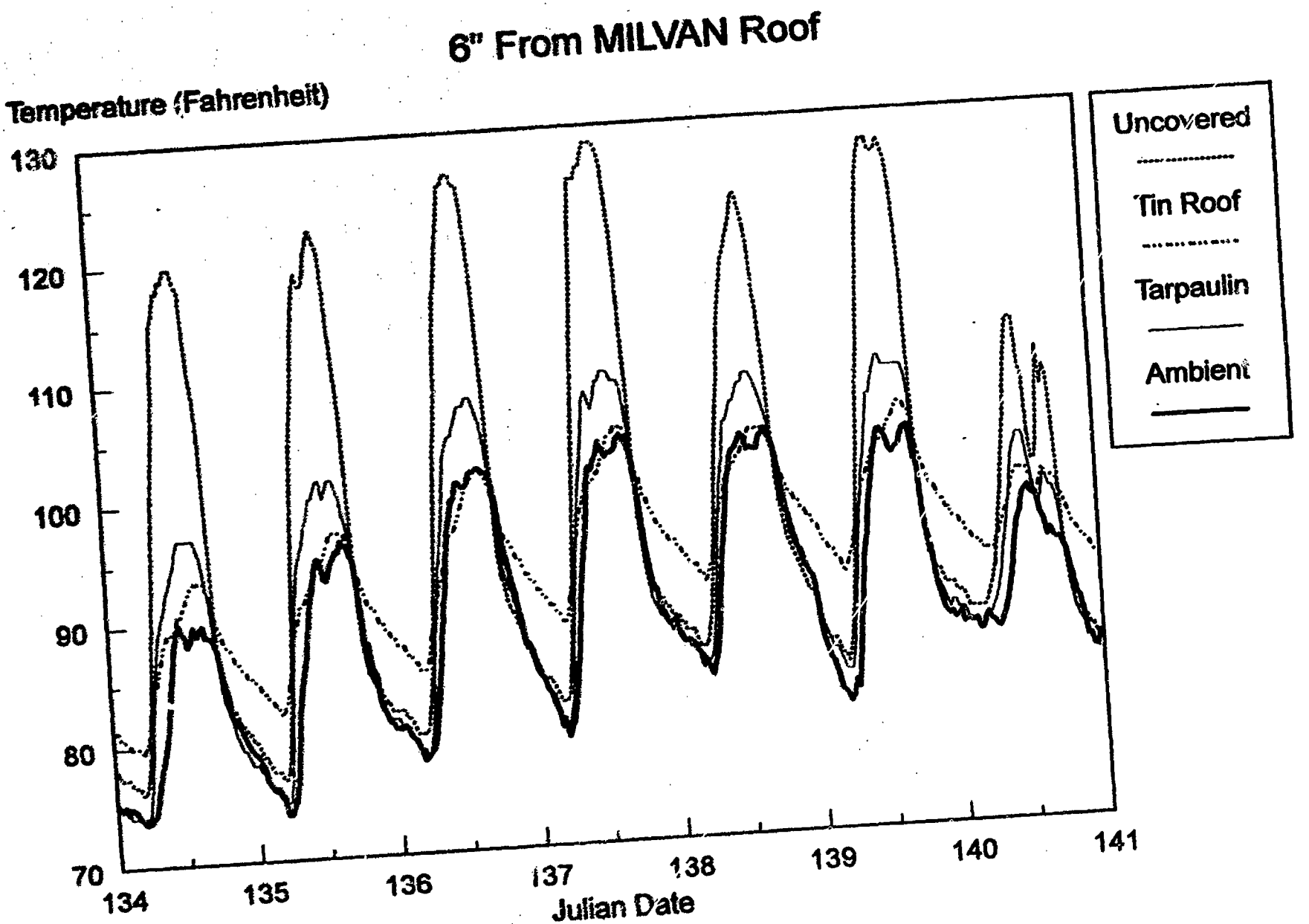
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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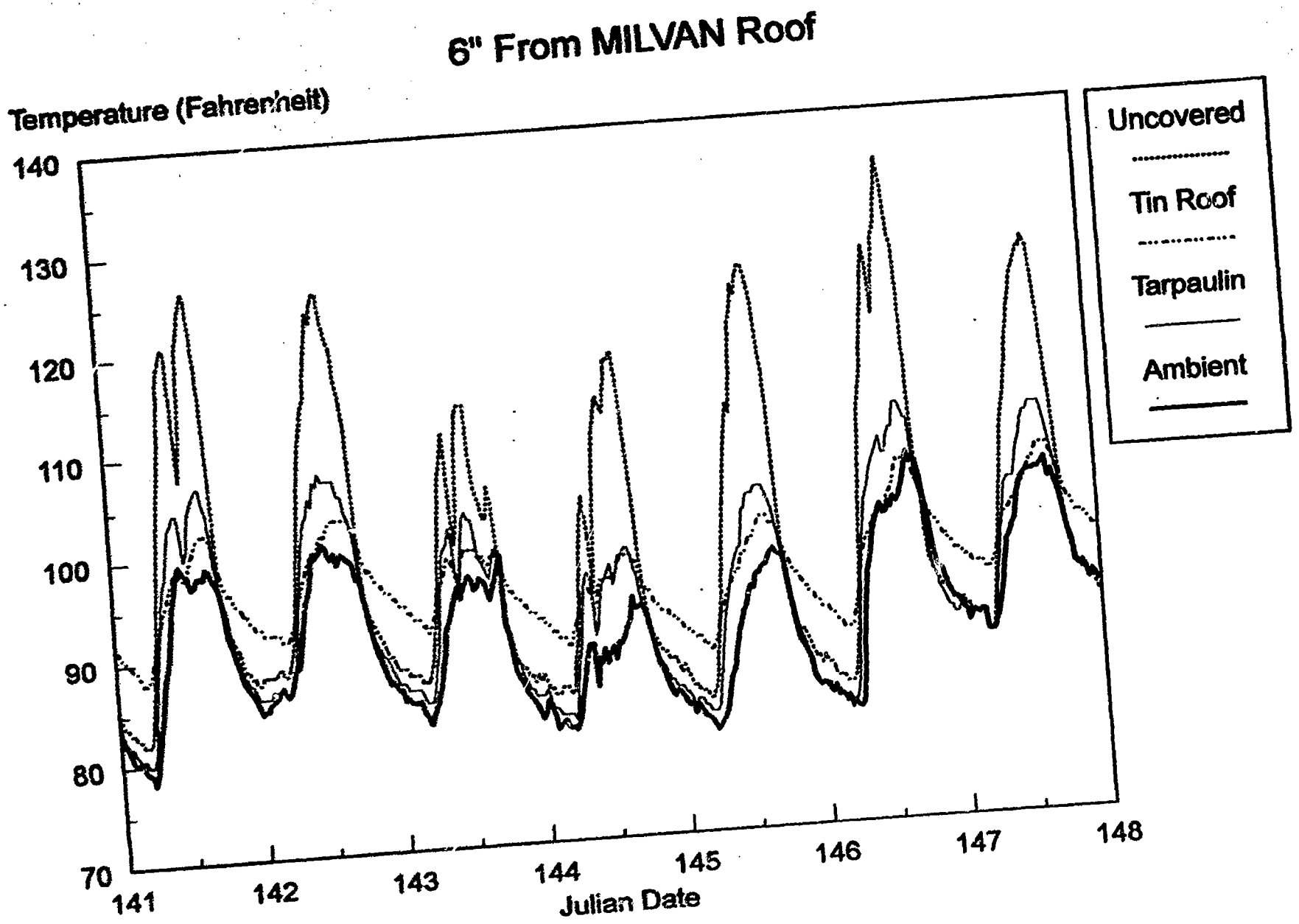
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
140
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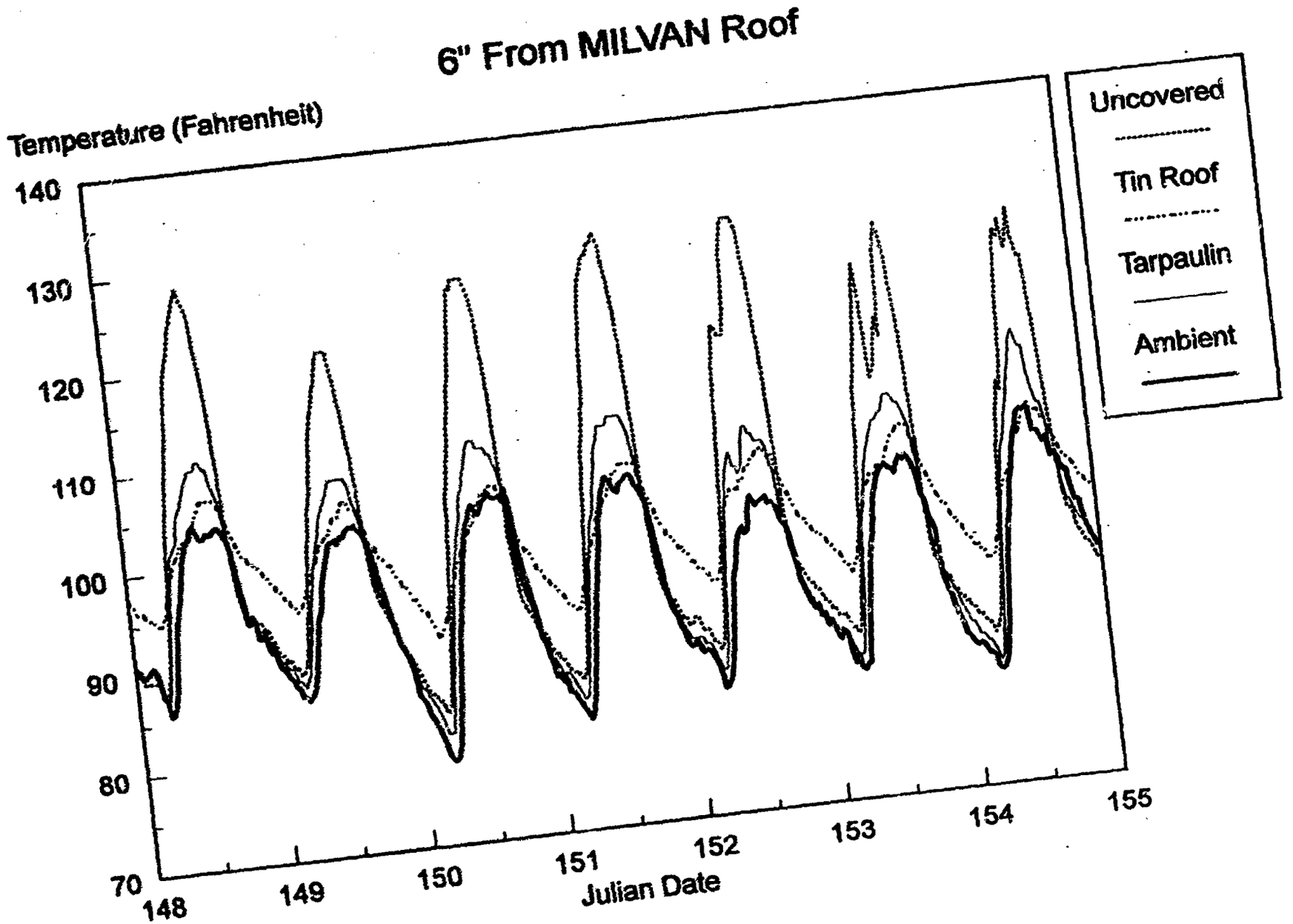
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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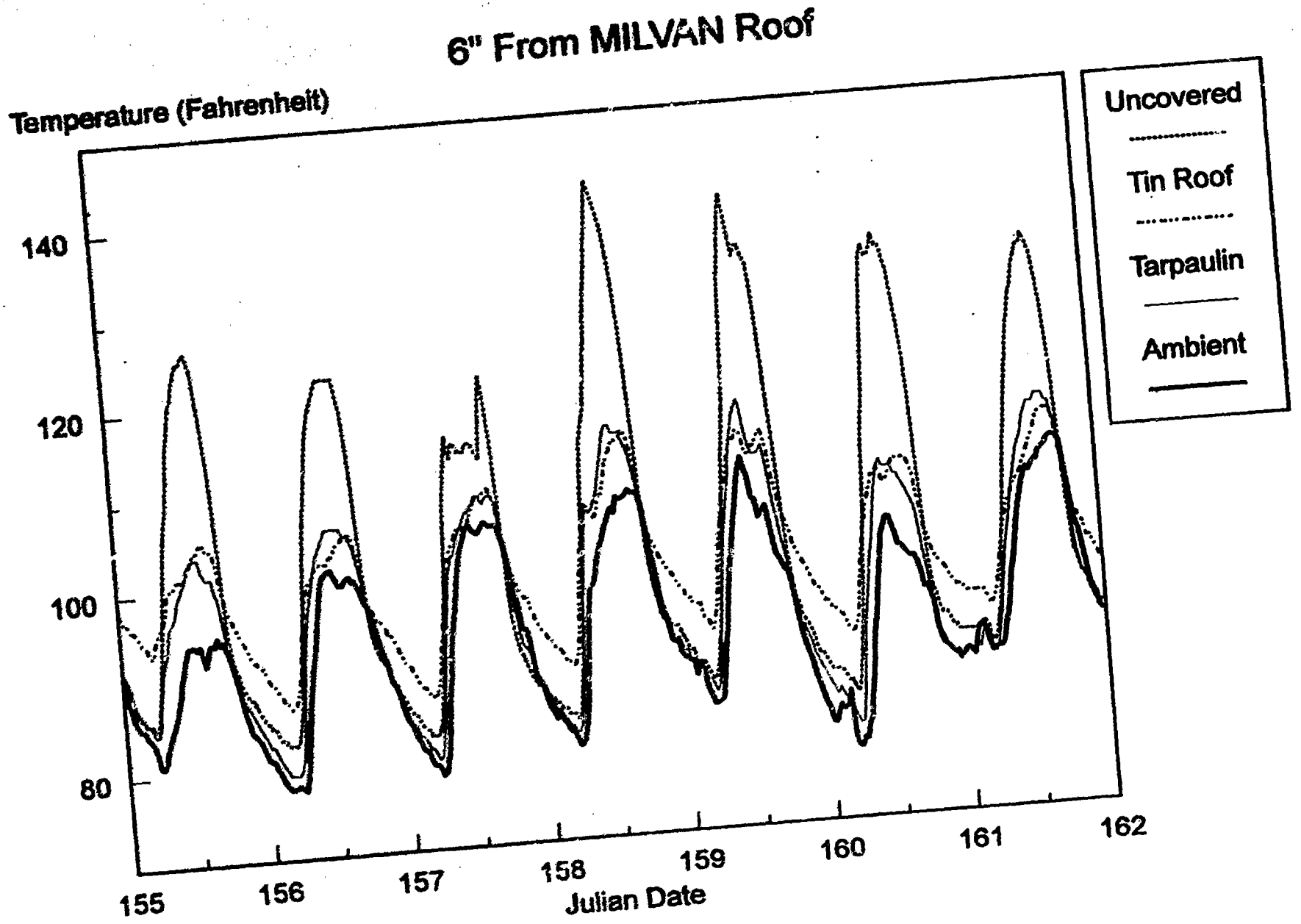
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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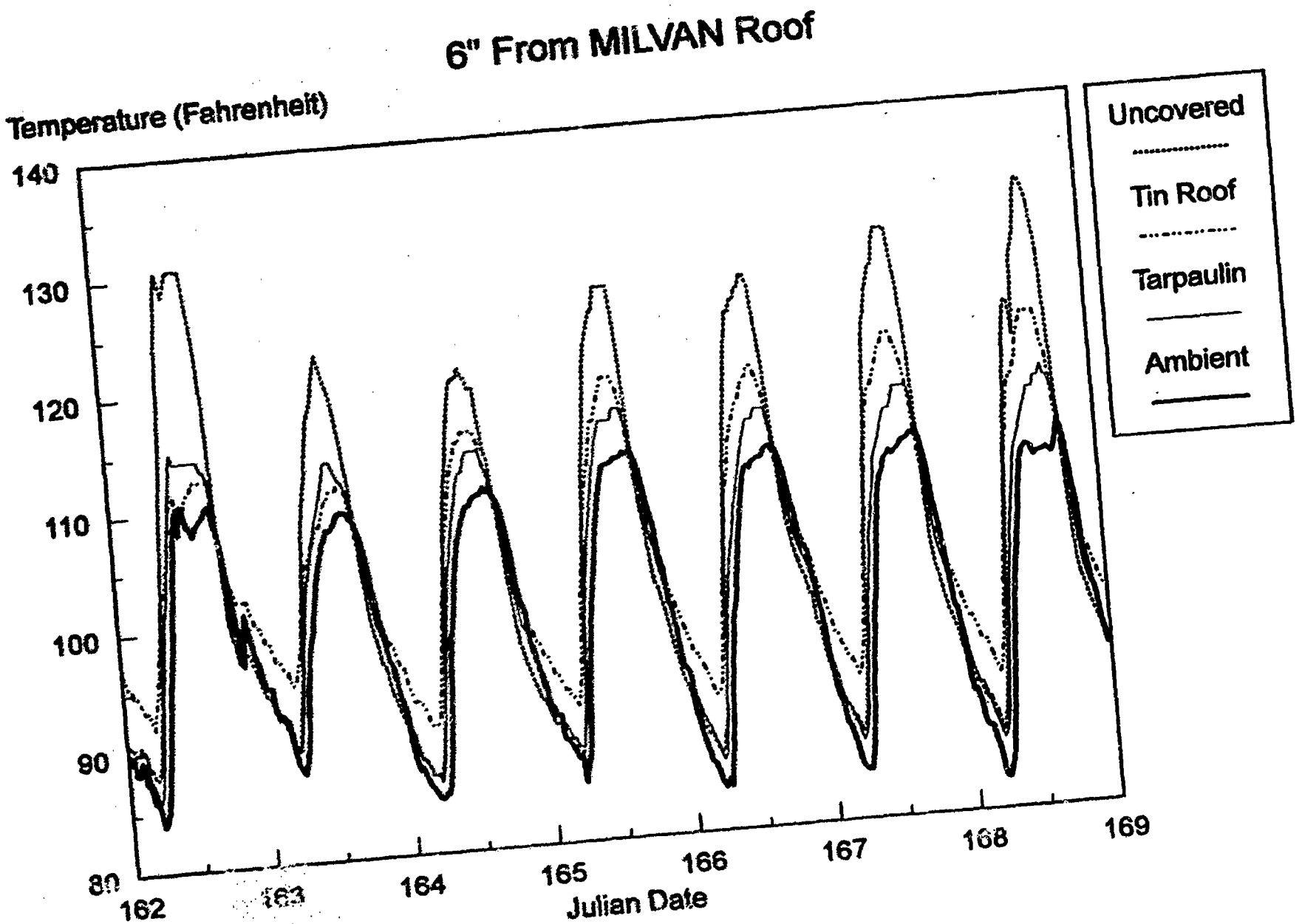
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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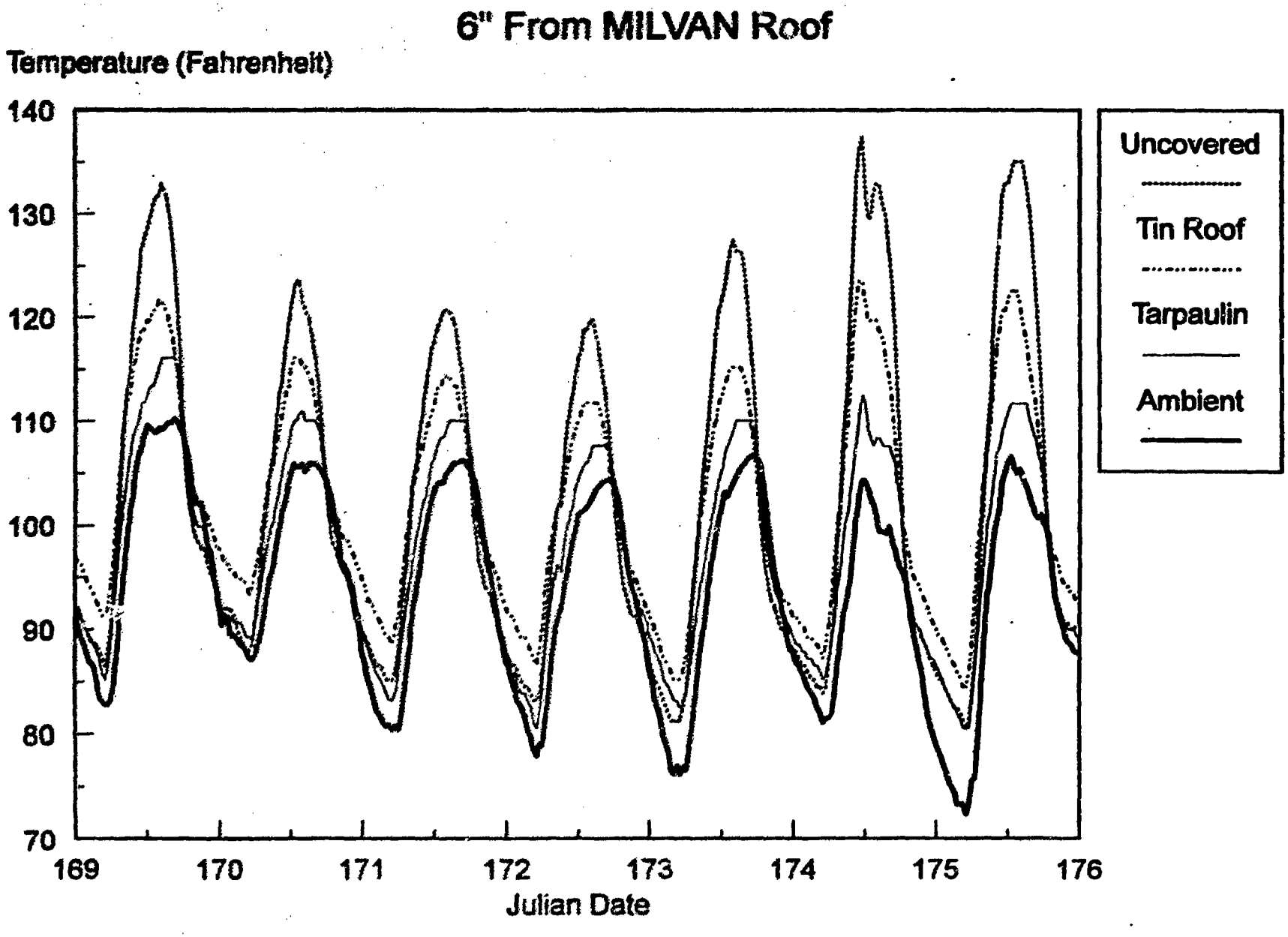
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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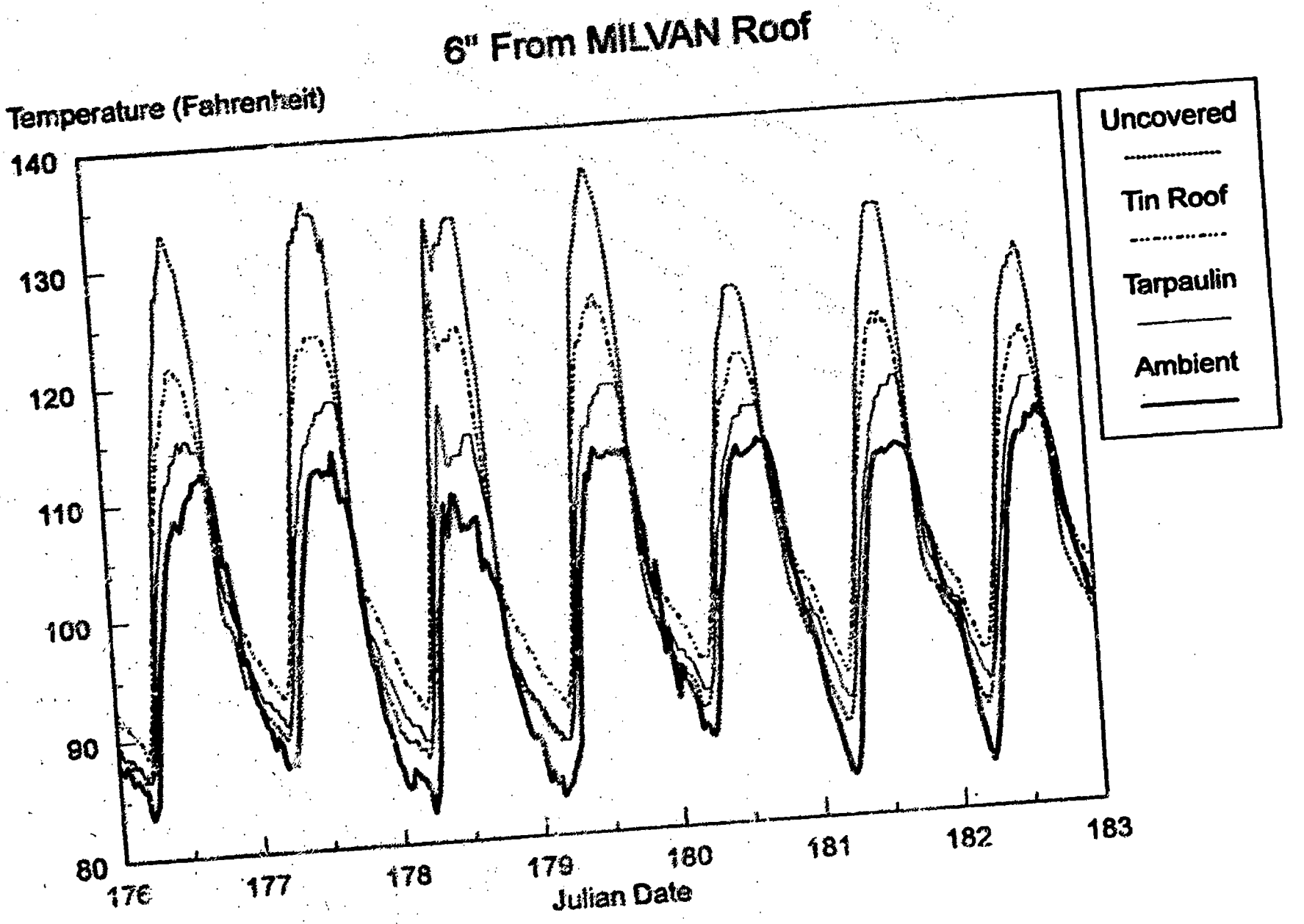
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient

6" From MILVAN Roof
Temperature (Fahrenheit)
140
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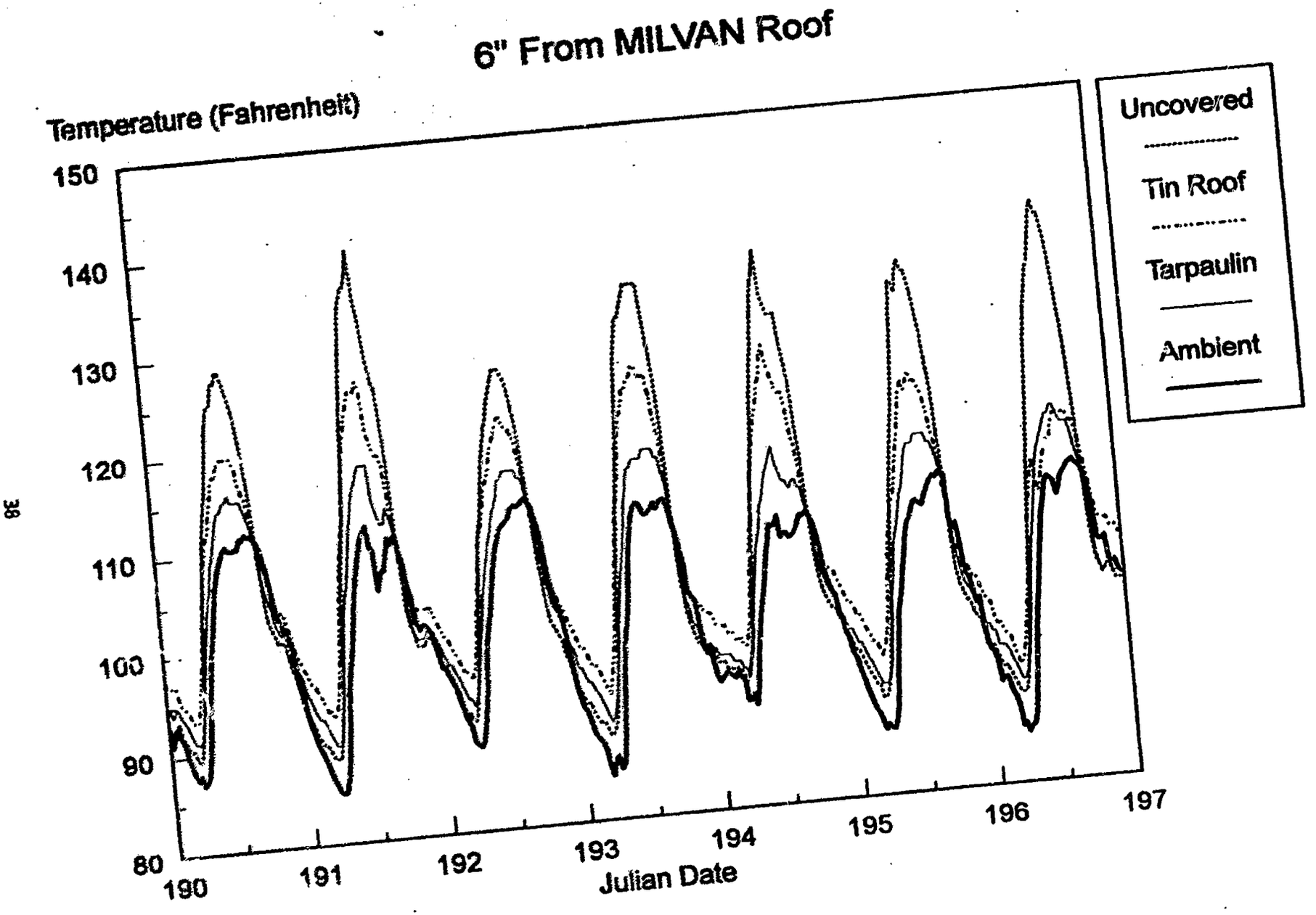
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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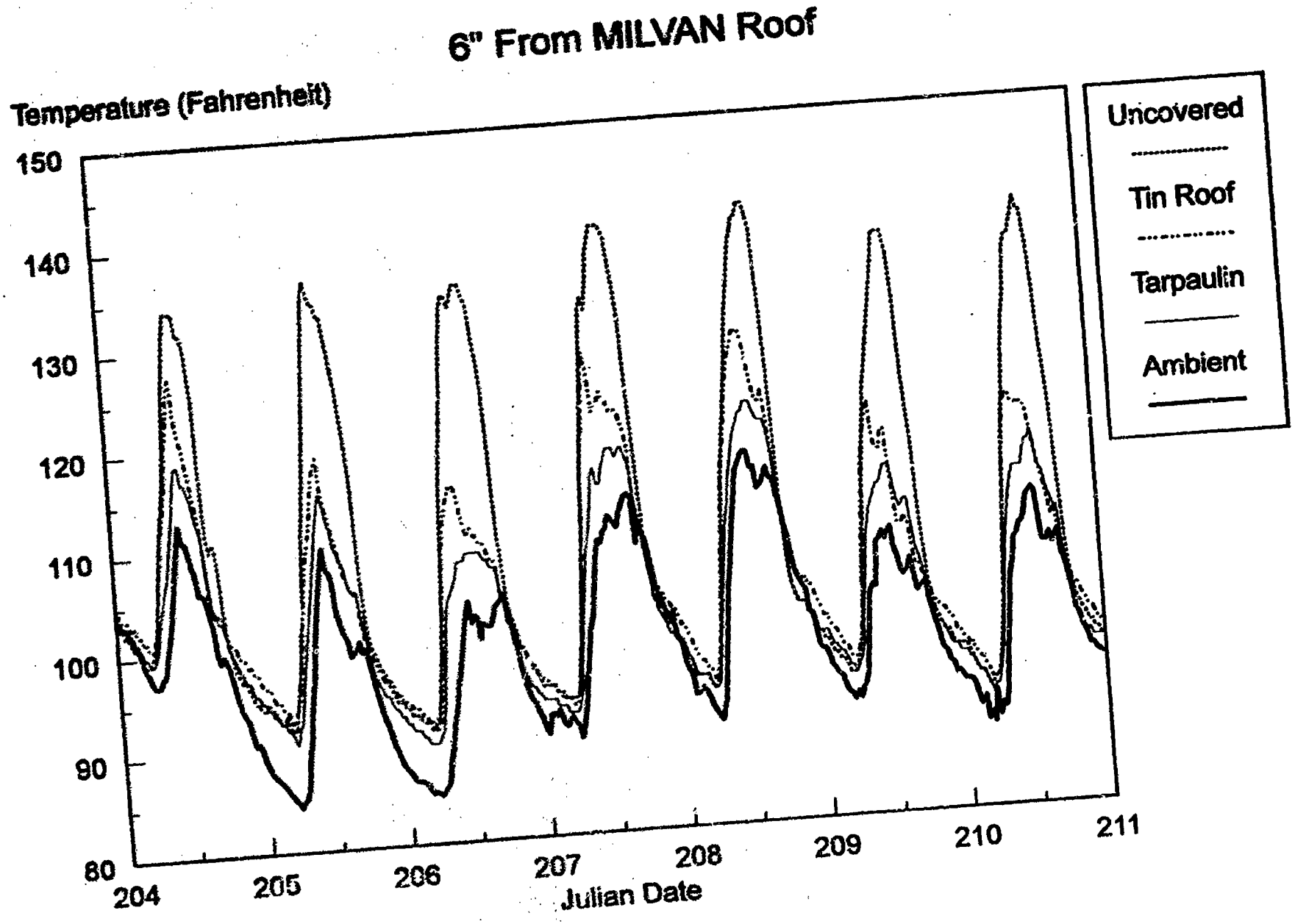
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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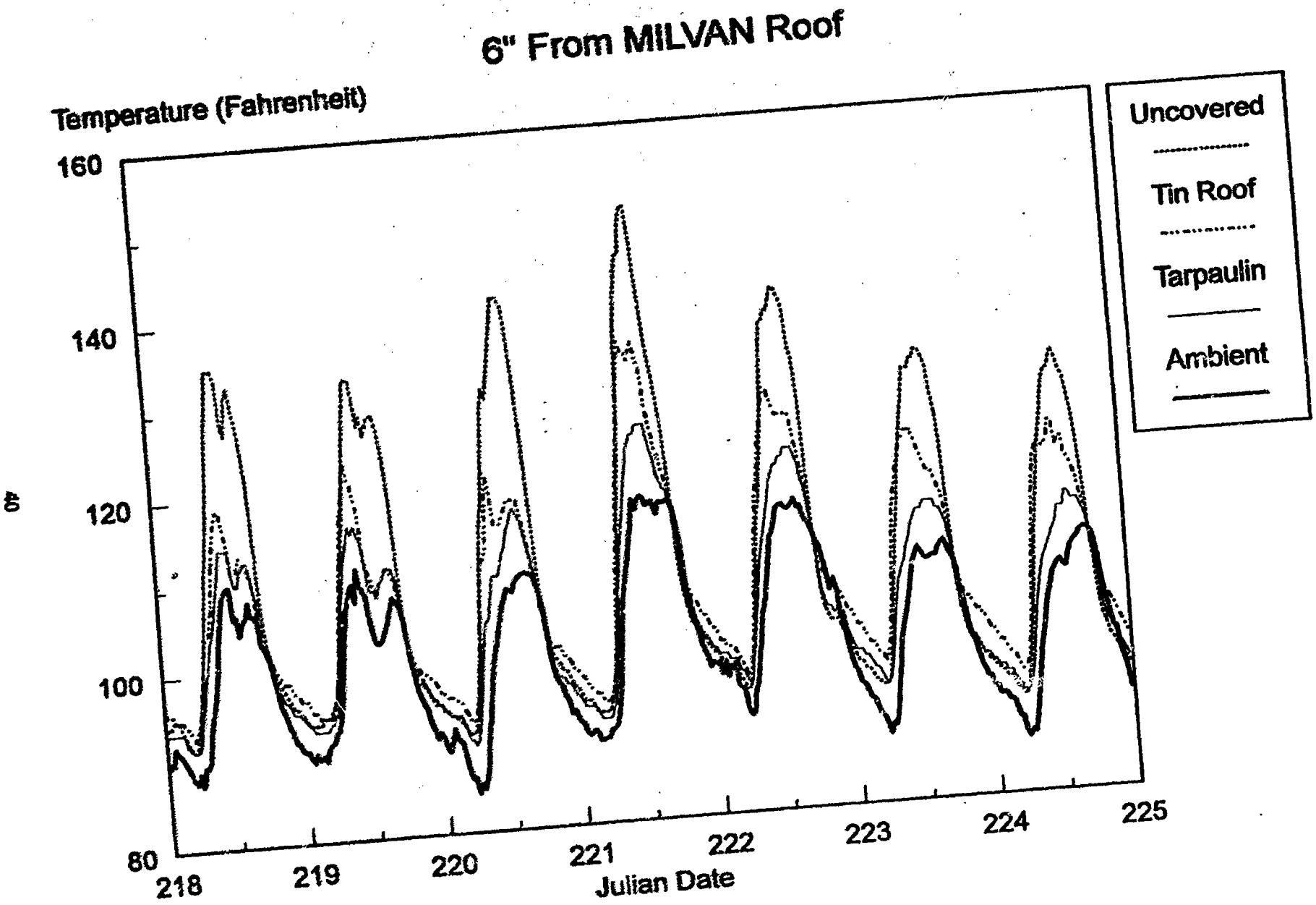
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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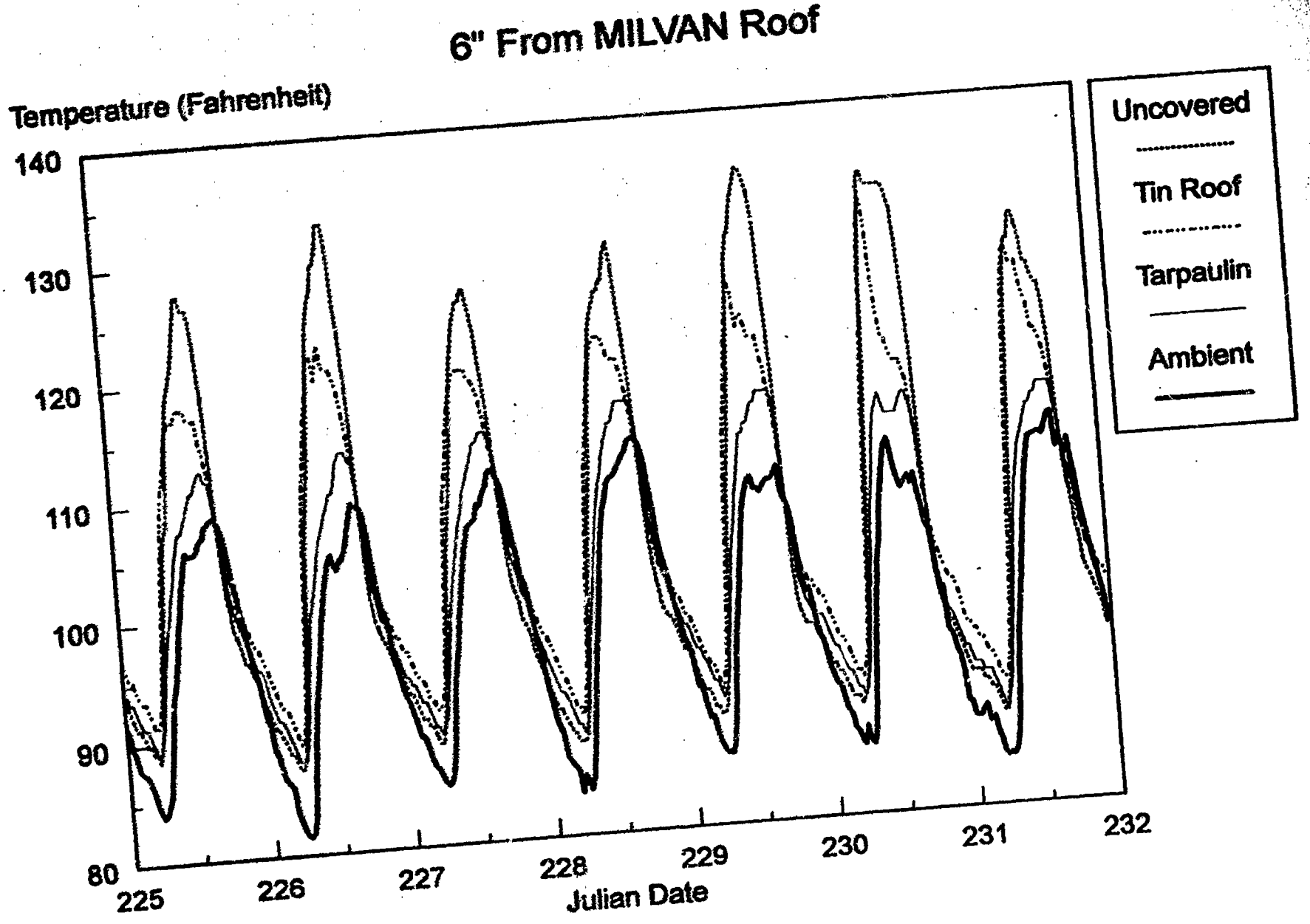
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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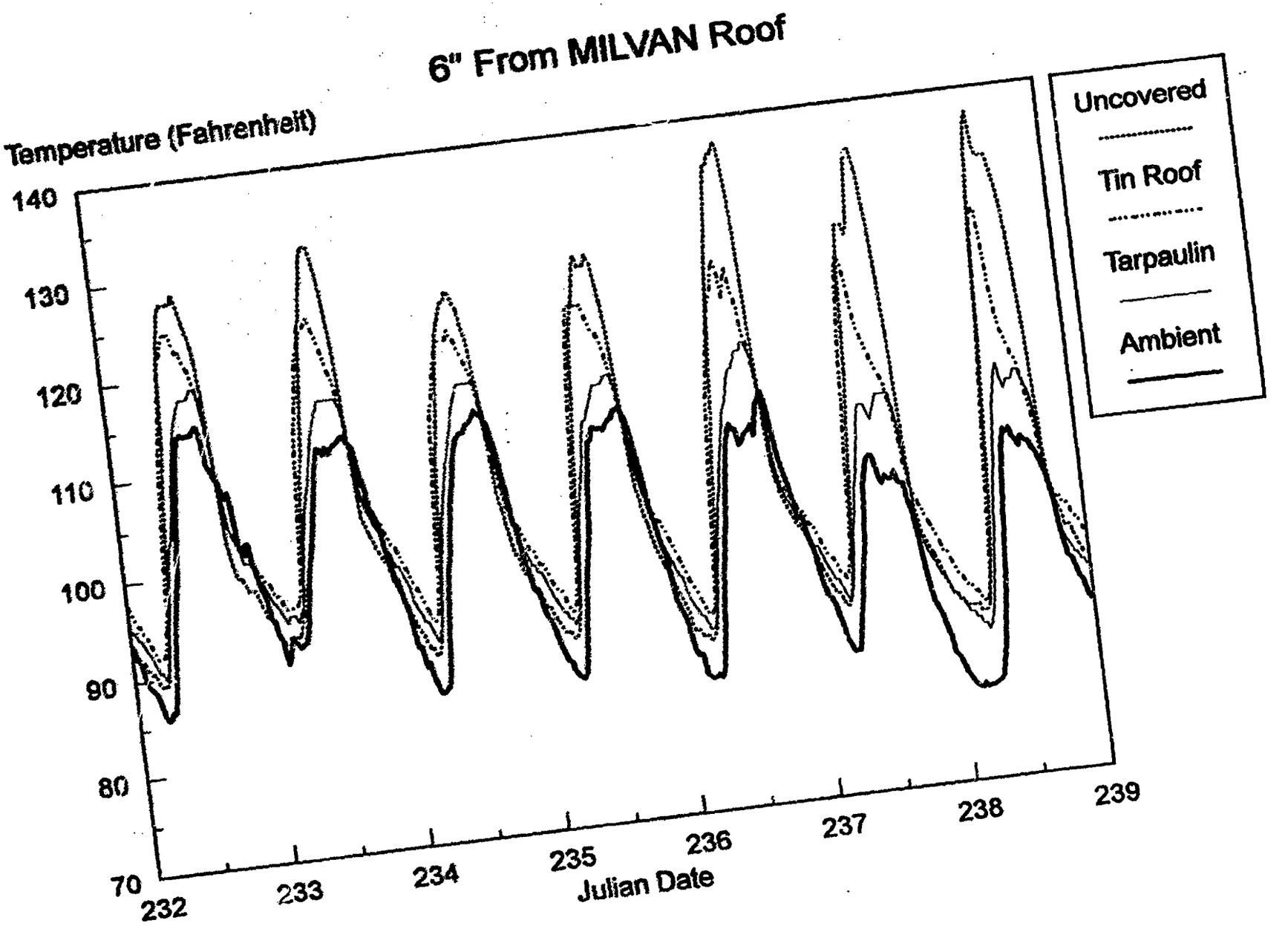
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
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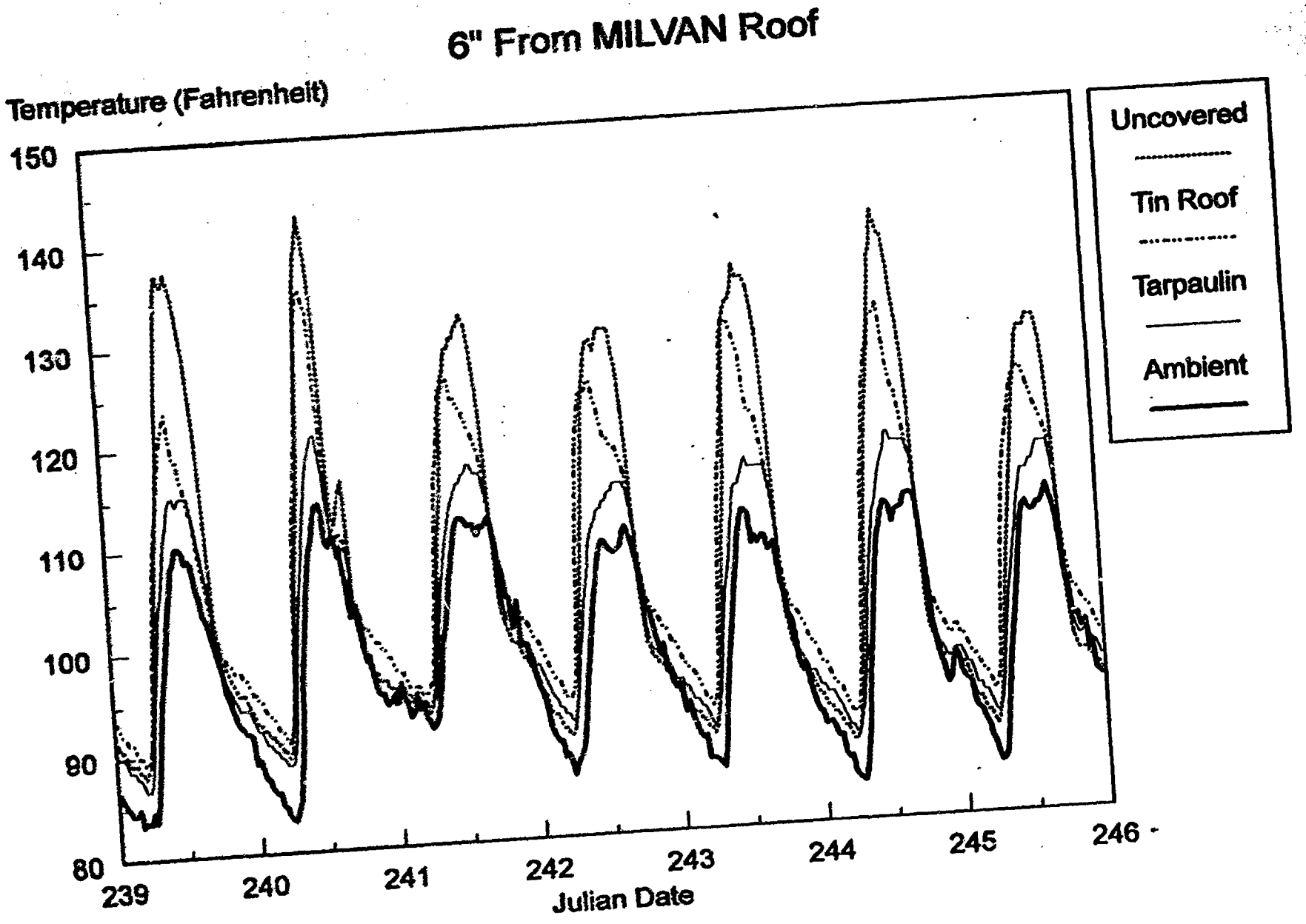
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
150
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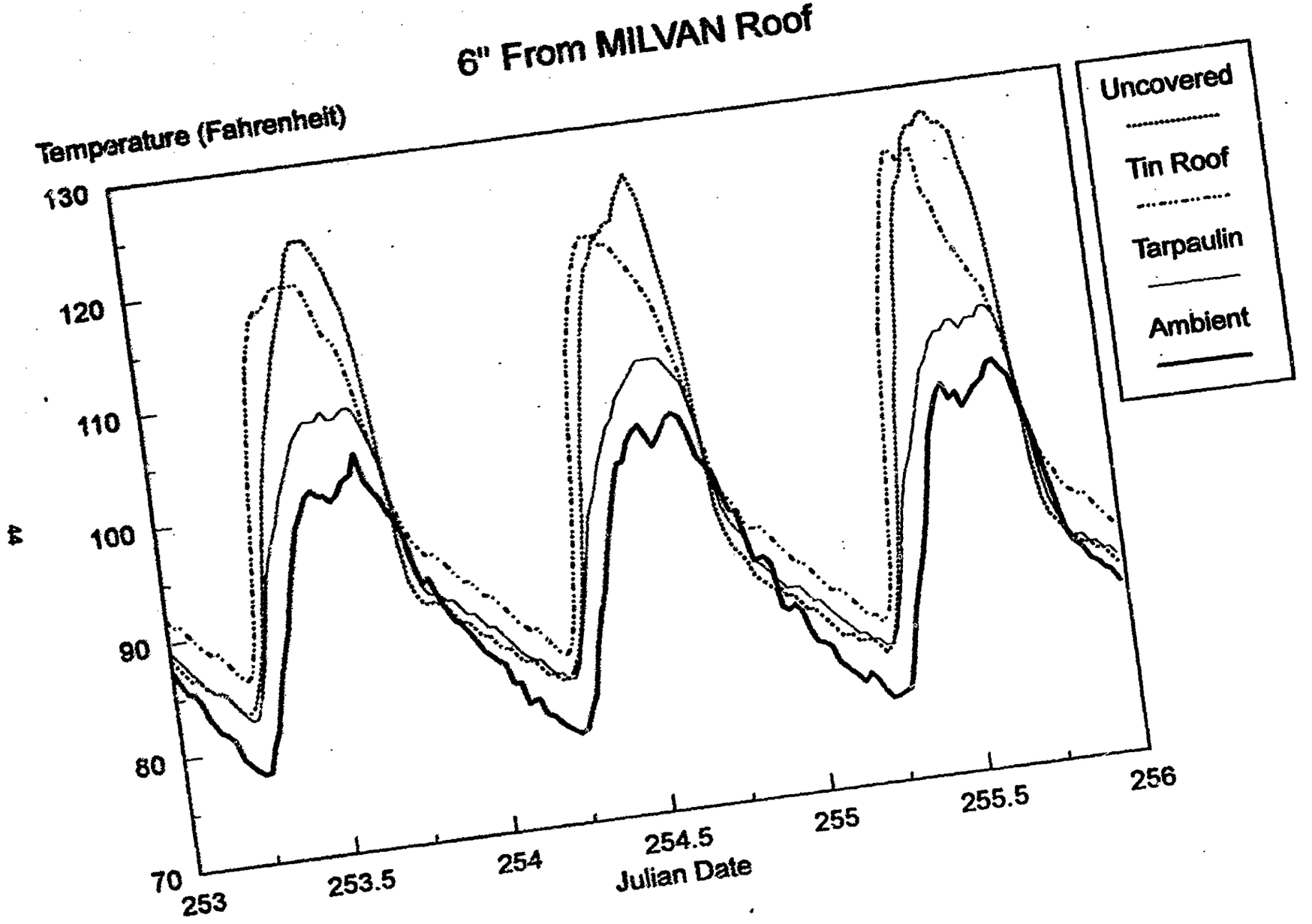
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


6" From MILVAN Roof
Temperature (Fahrenheit)
130
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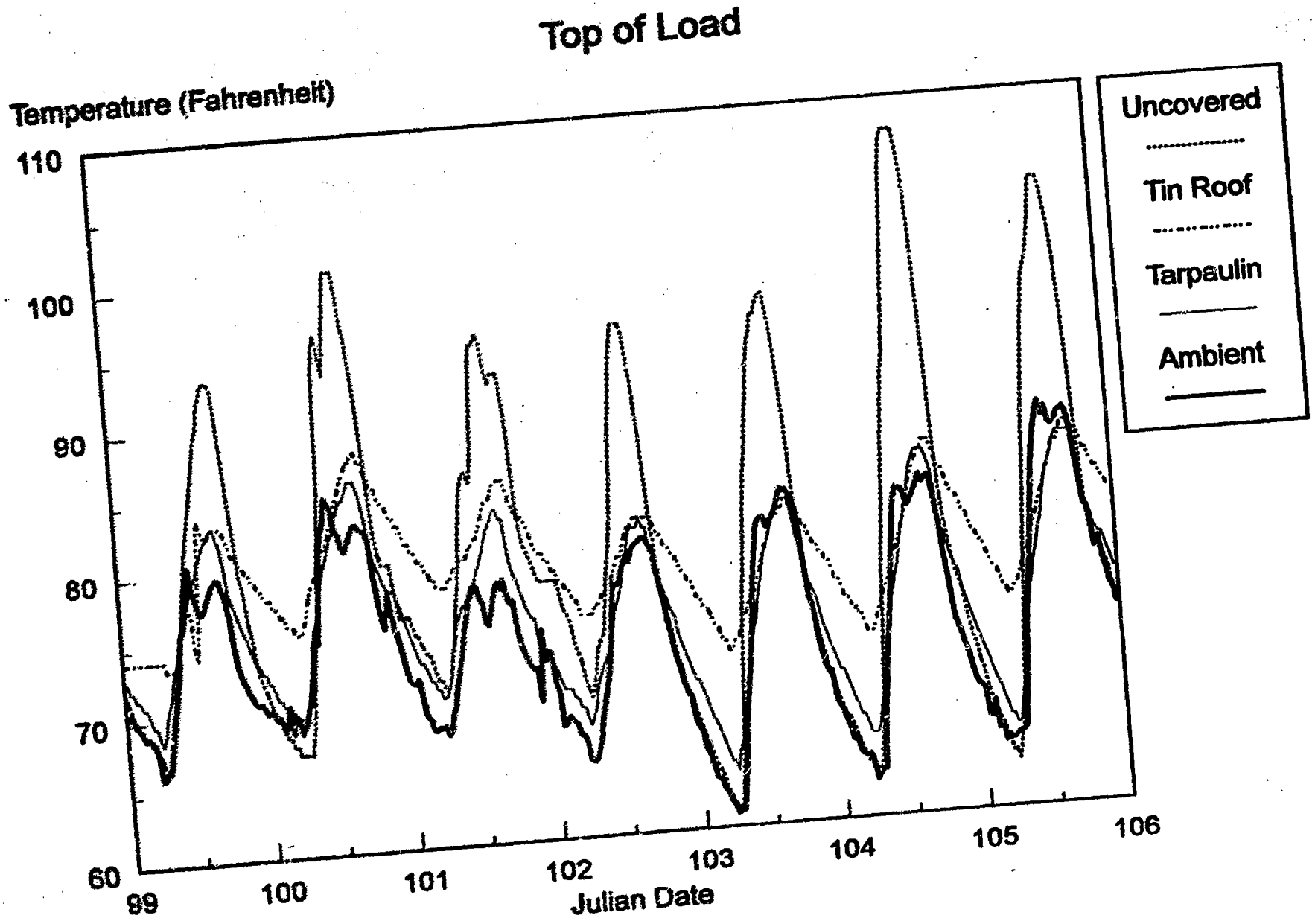
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
110
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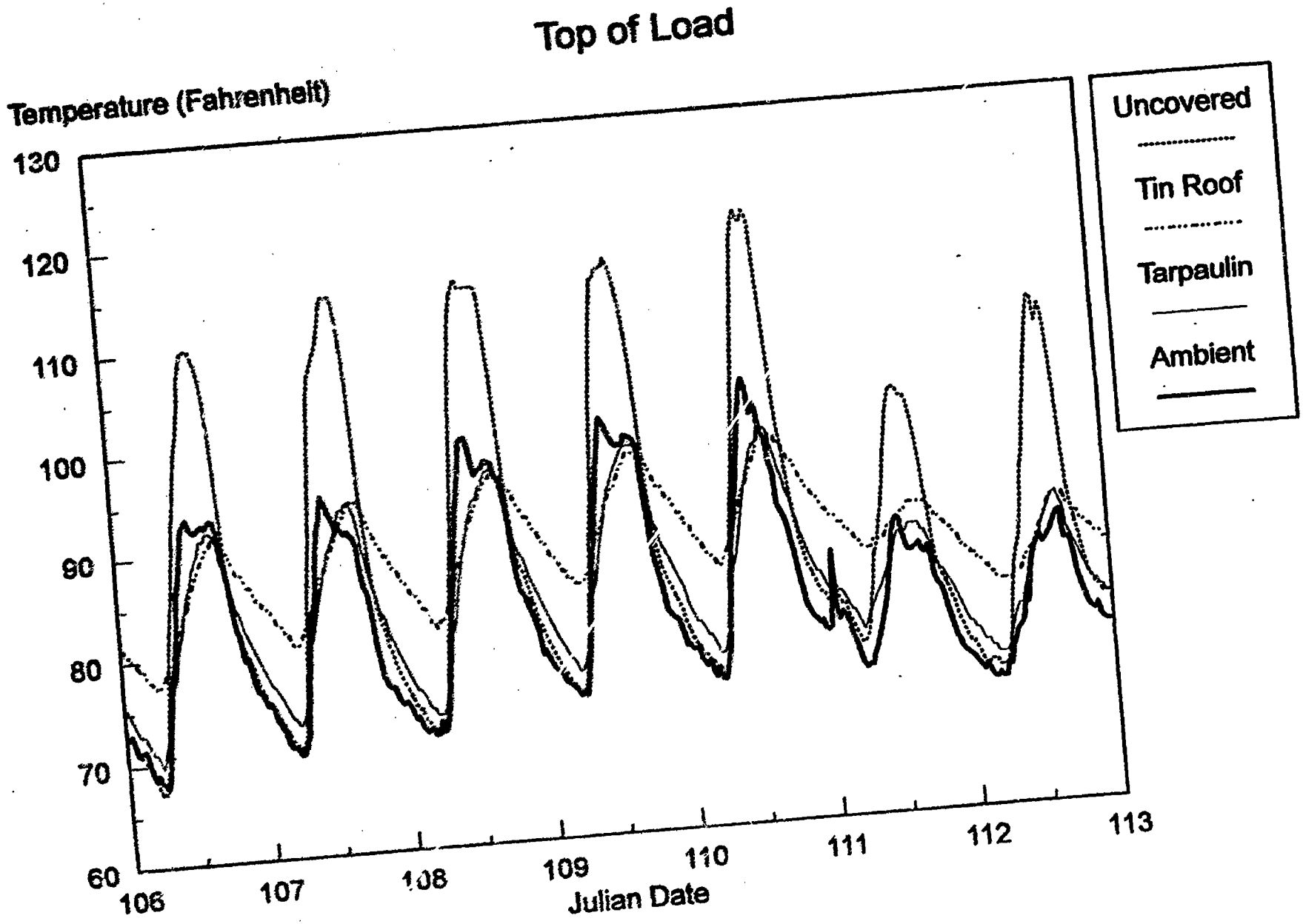
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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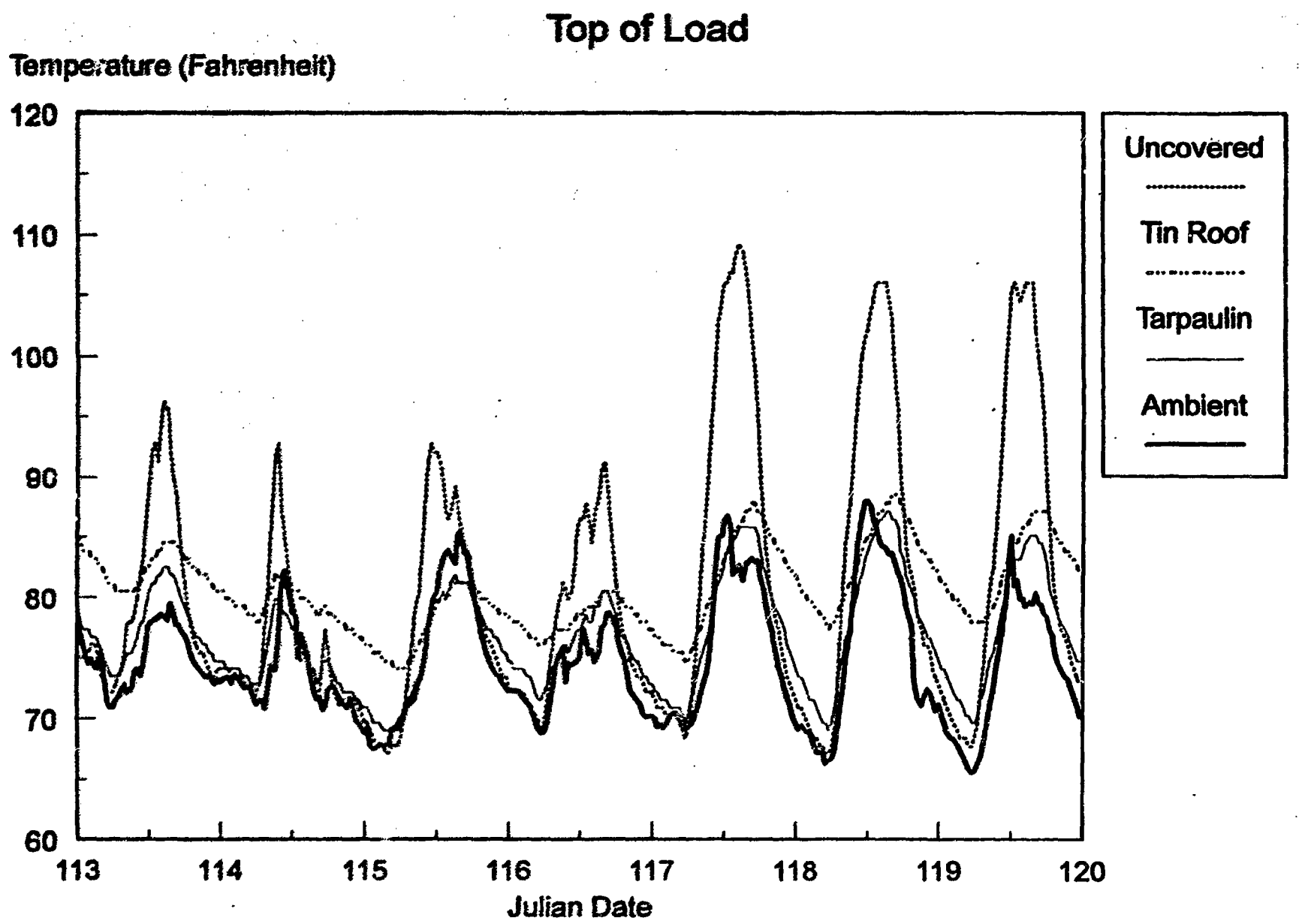
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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Julian Date
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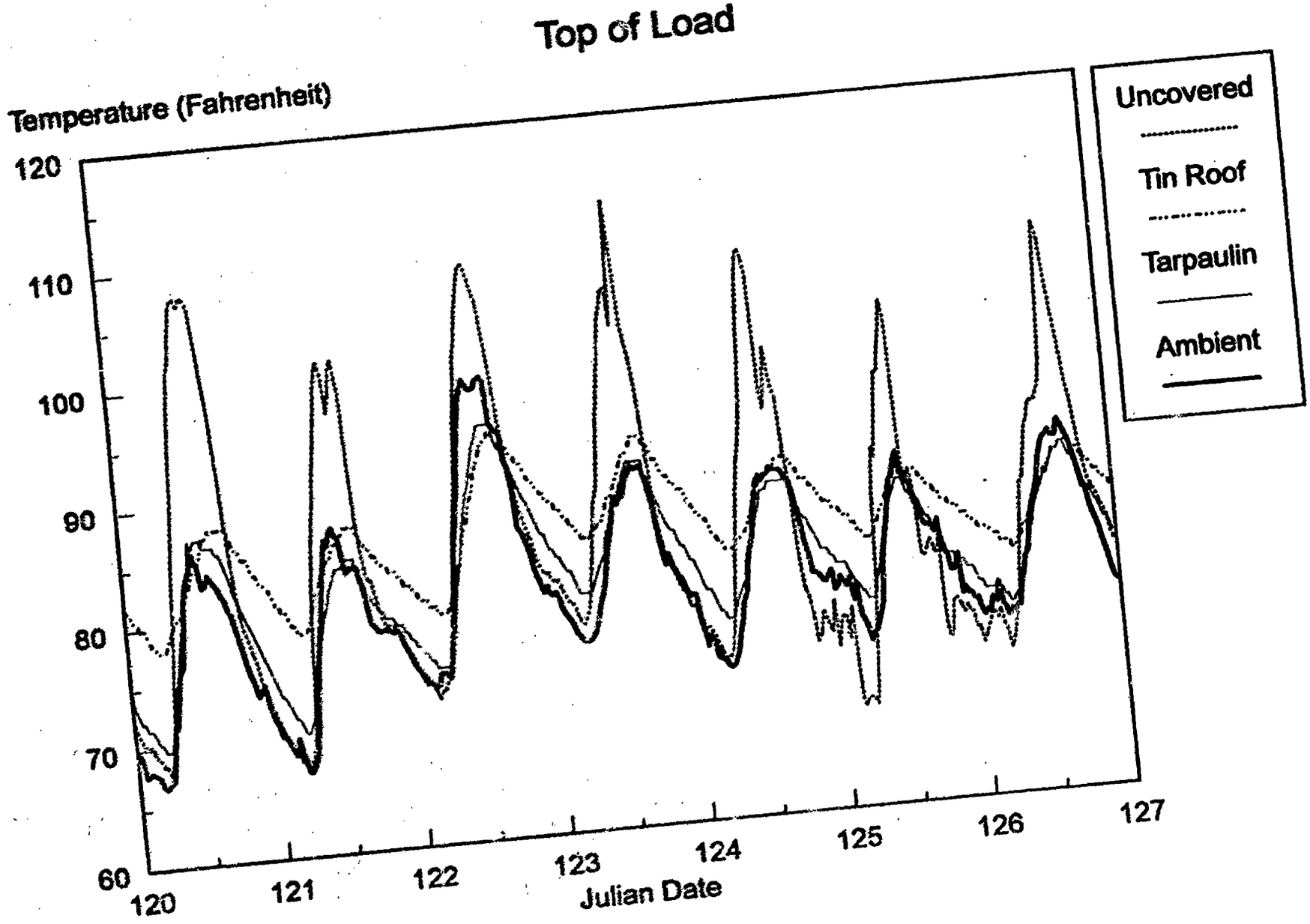
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient

Top of Load
Uncovered
Tin Roof
Tarpaulin
Ambient
Temperature (Fahrenheit)
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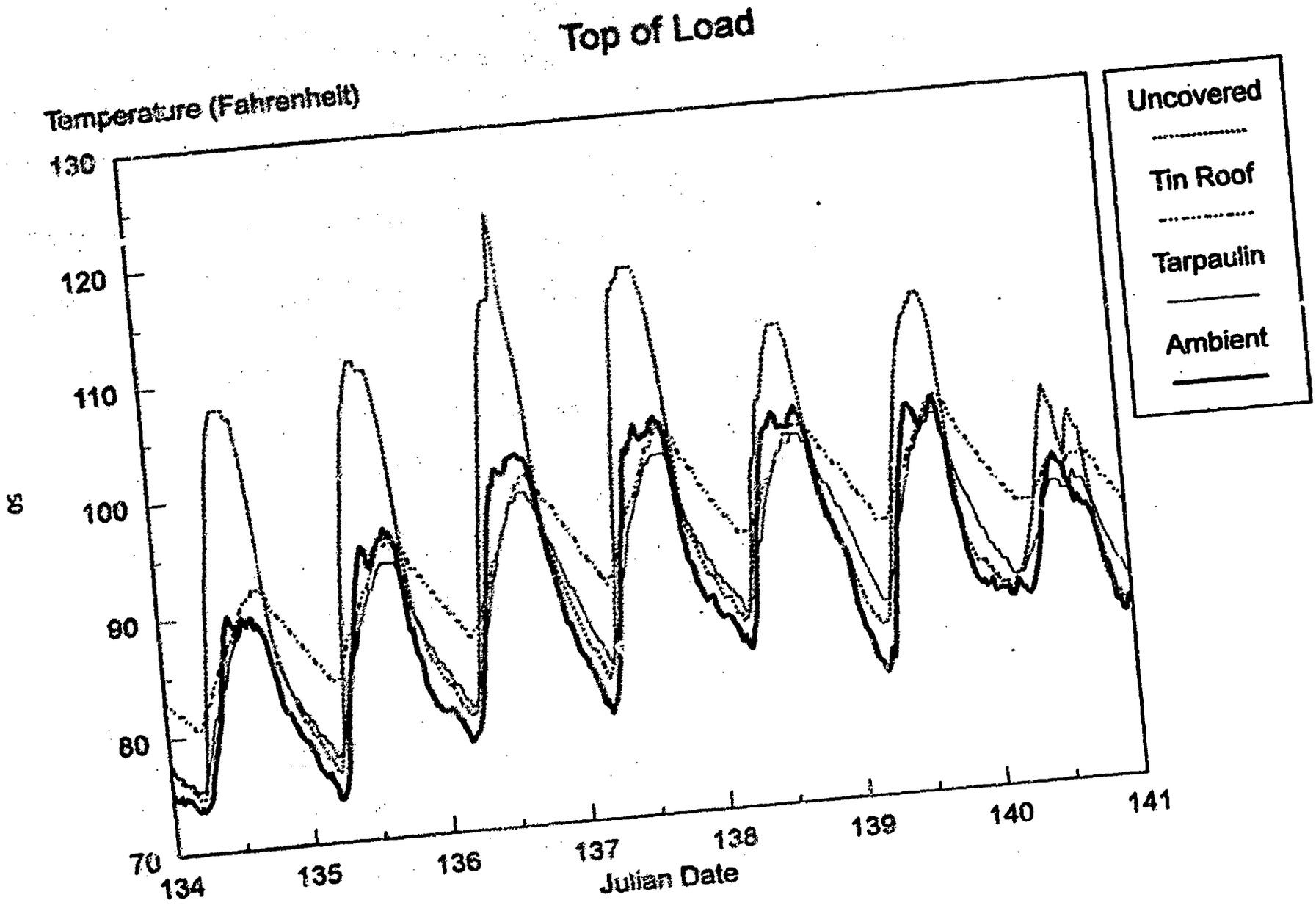
Julian Date


Top of Load
Temperature (Fahrenheit)
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Julian Date
Uncovered
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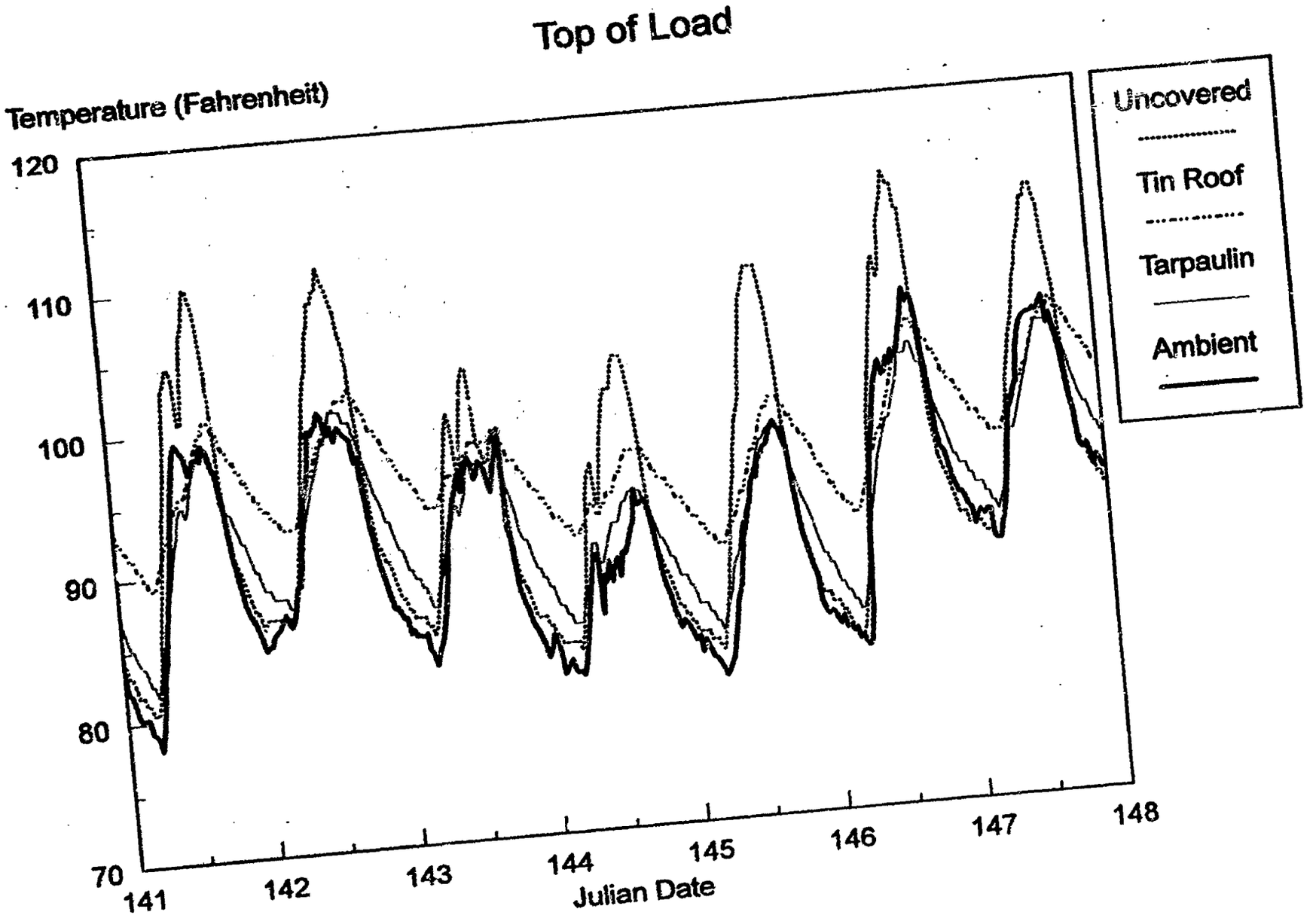
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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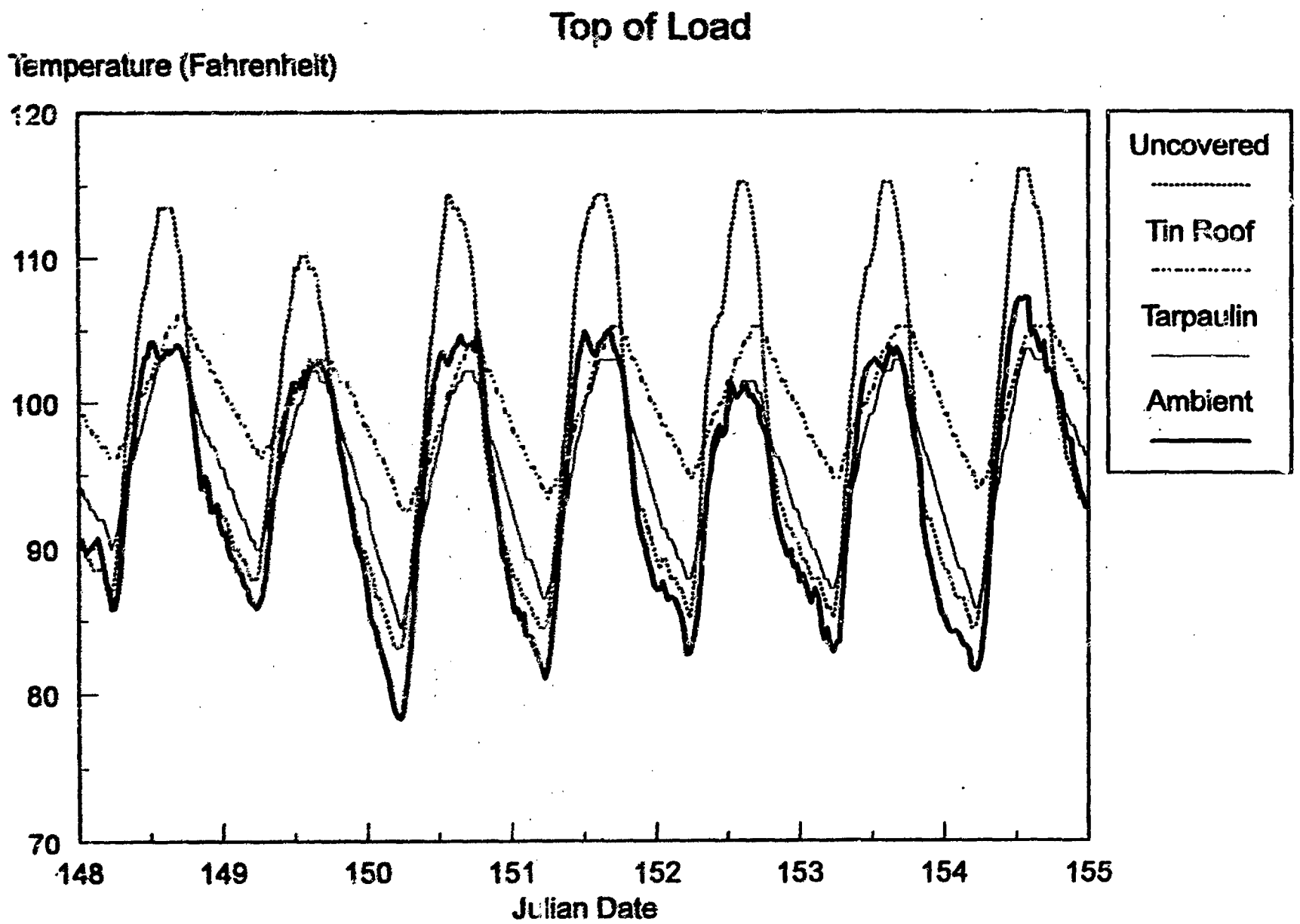
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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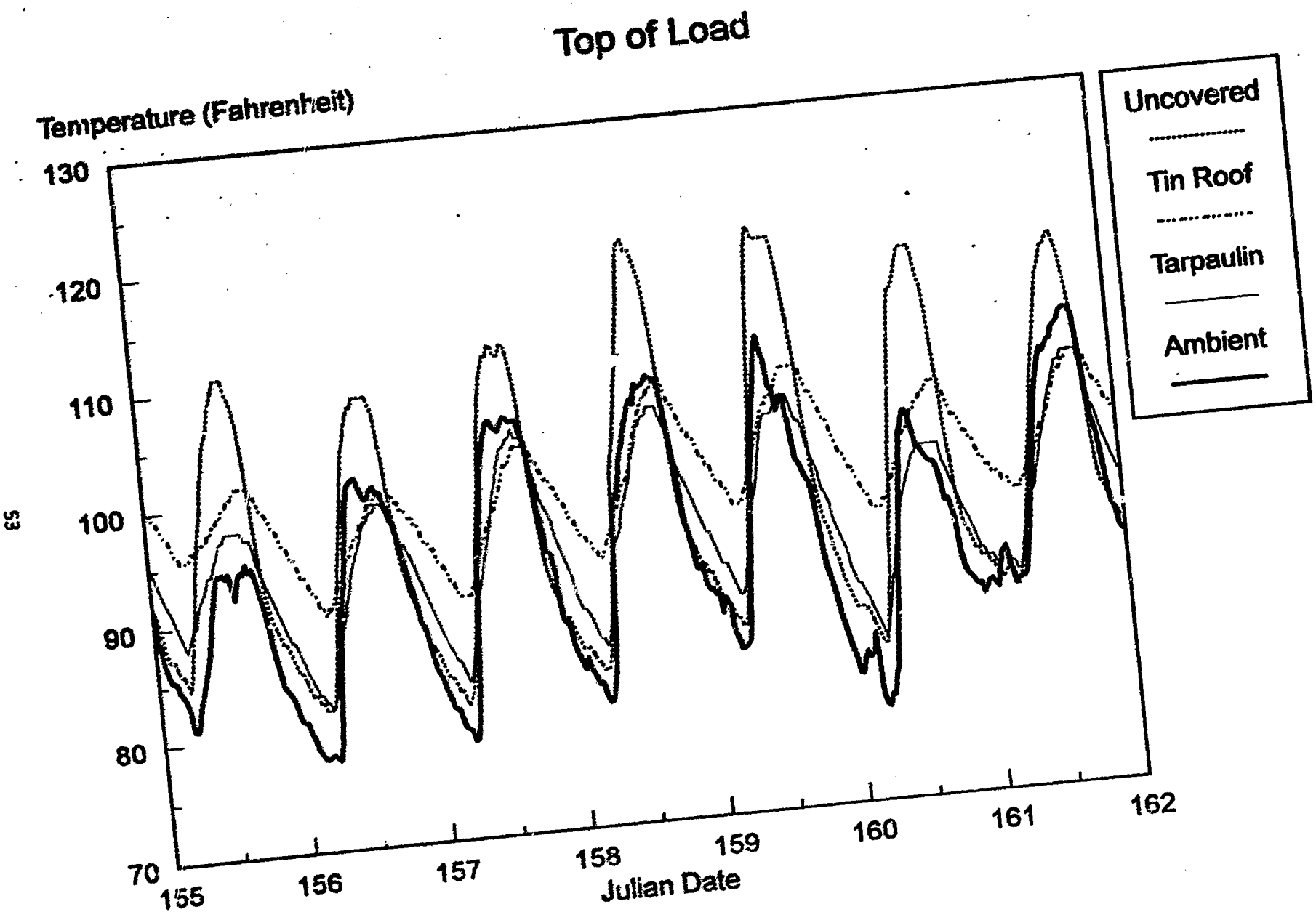
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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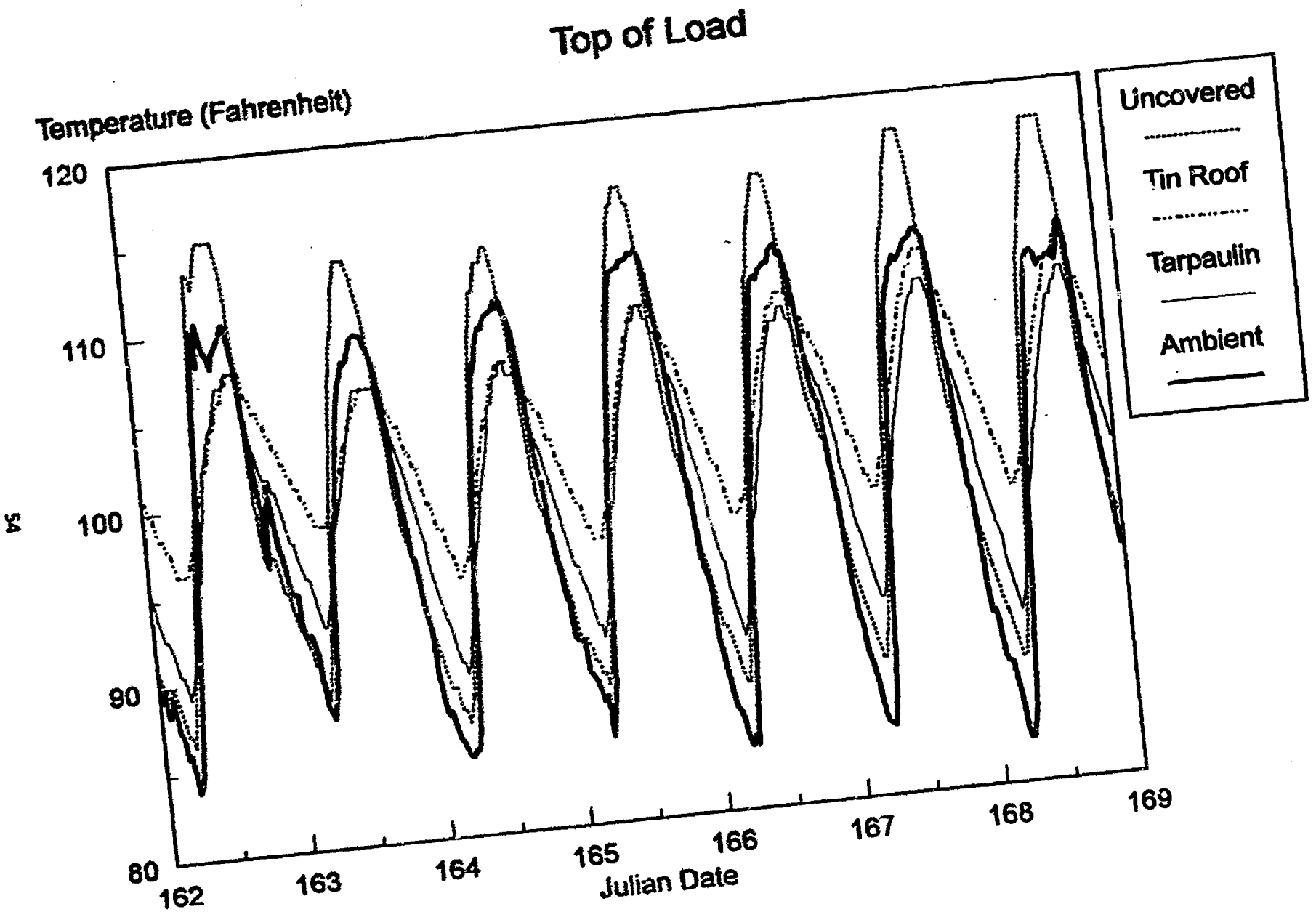
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient

Top of Load
Uncovered
Tin Roof
Tarpaulin
Ambient
Temperature (Fahrenheit)
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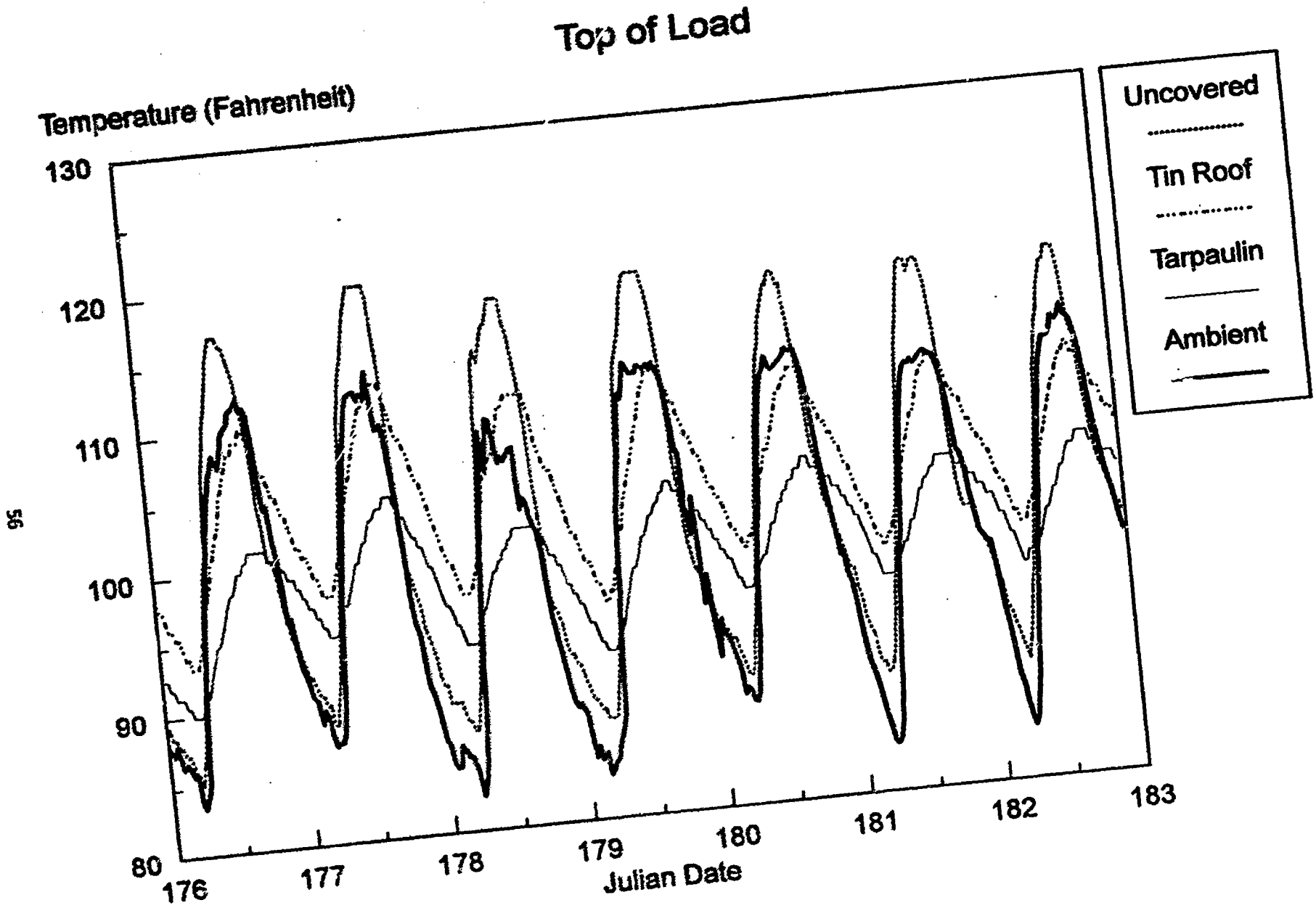
Julian Date


Top of Load
Temperature (Fahrenheit)
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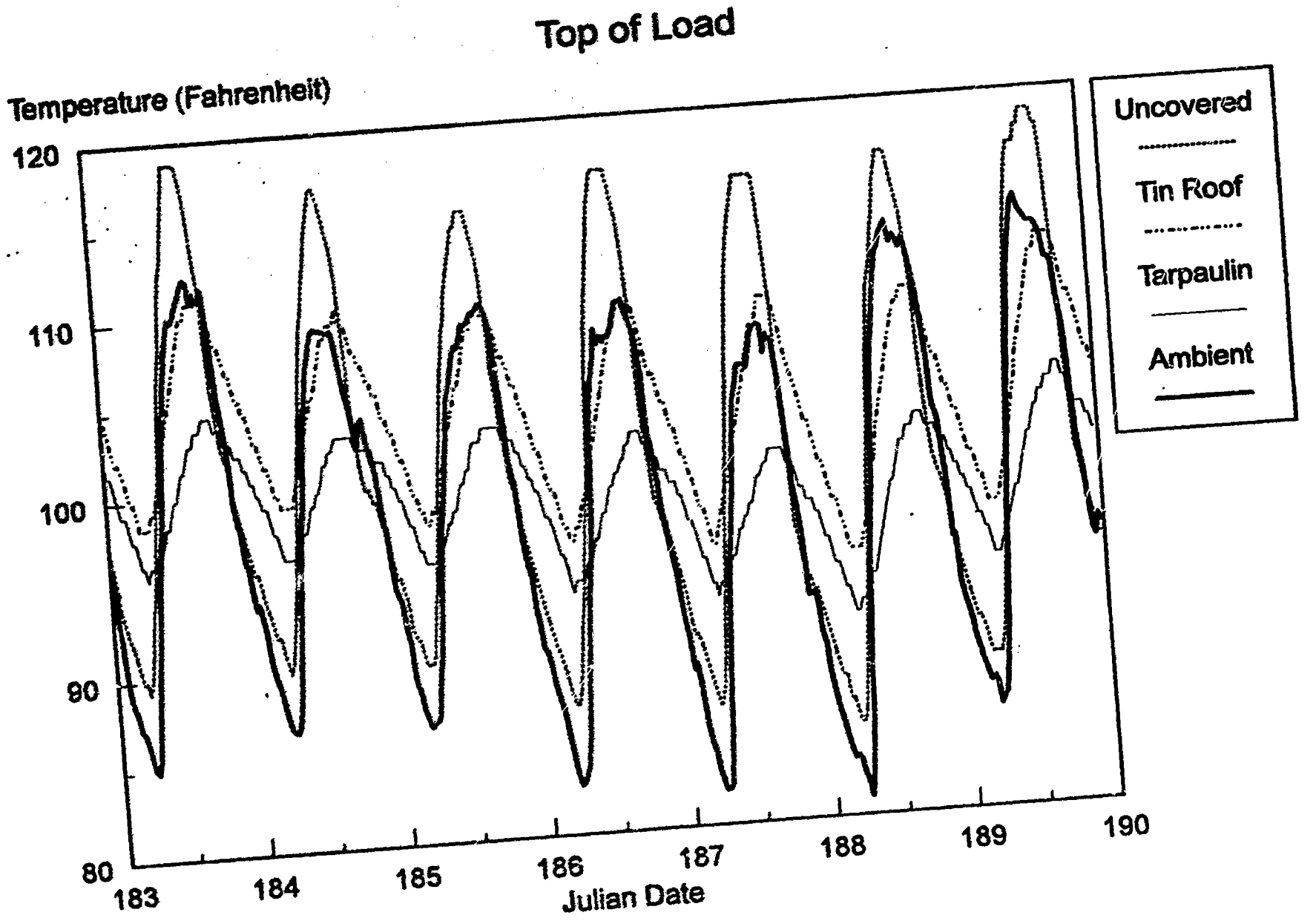
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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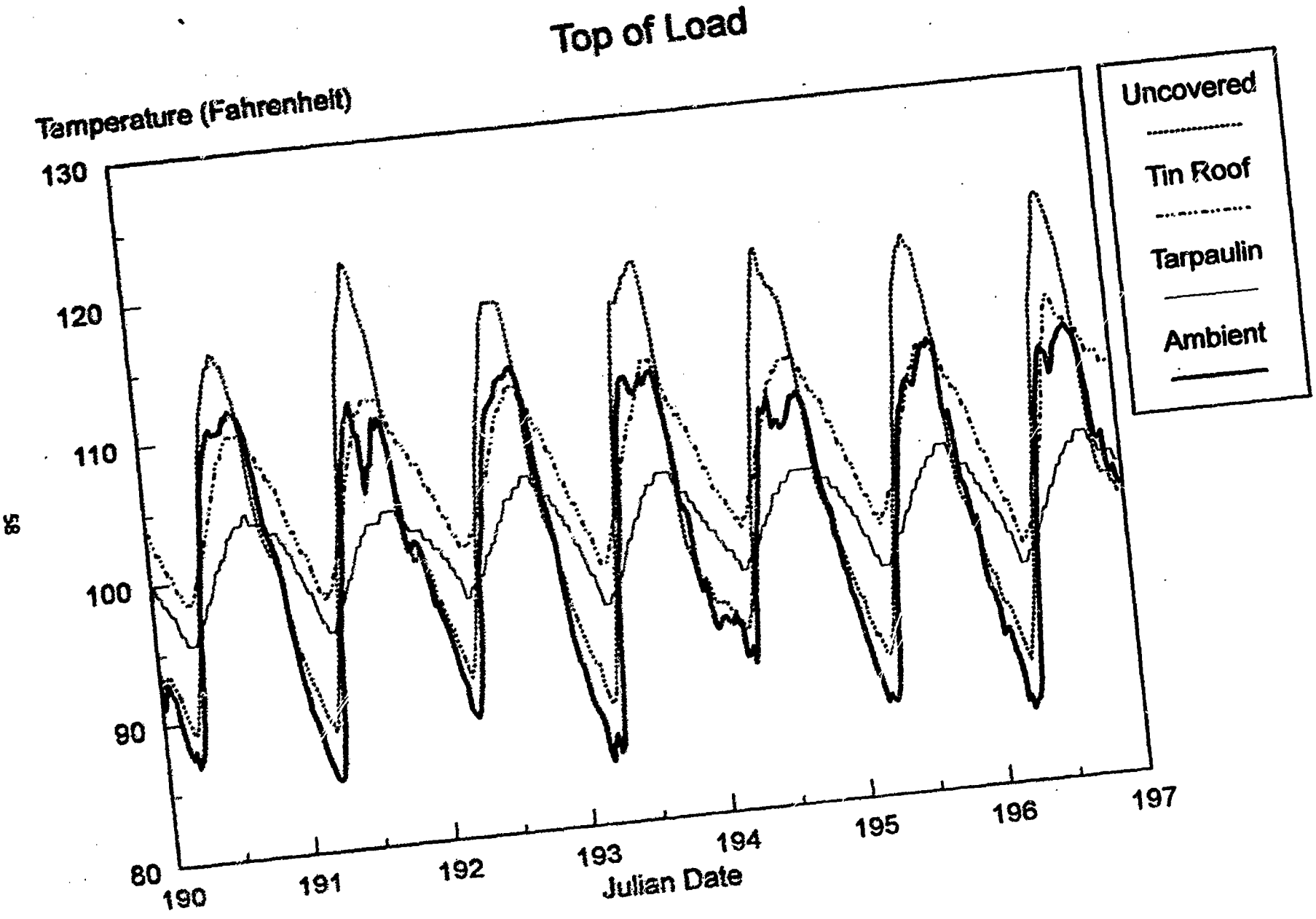
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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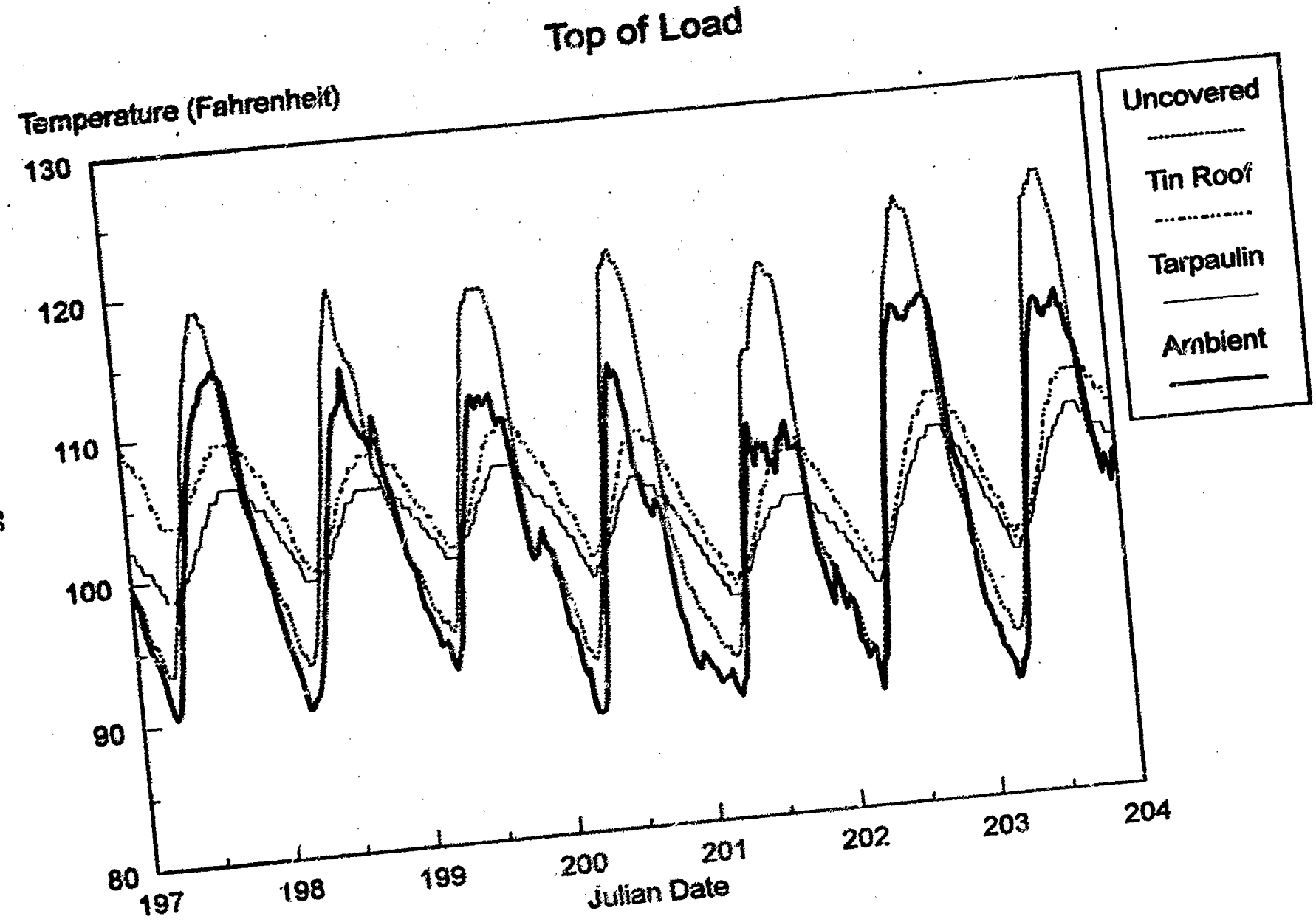
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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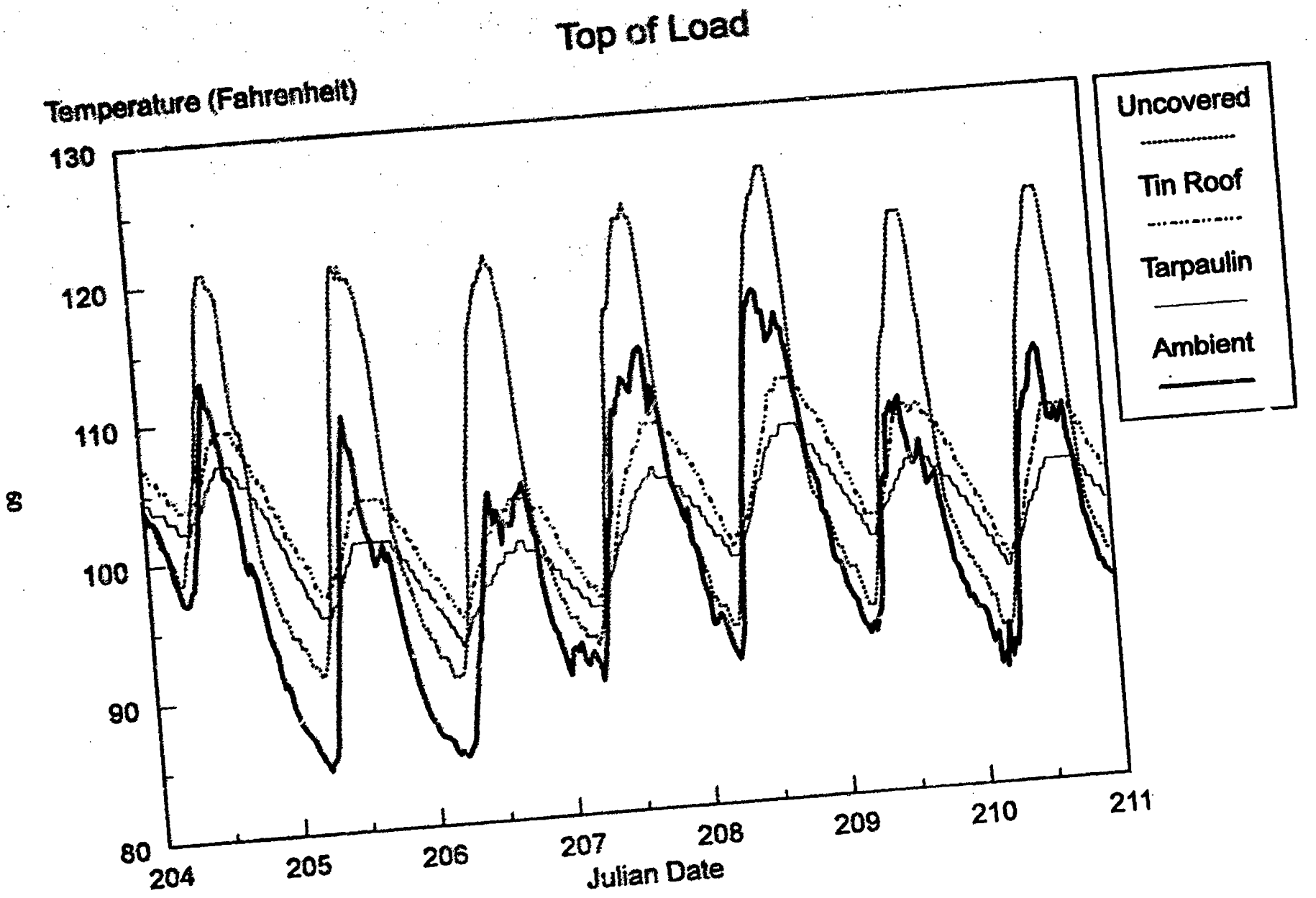
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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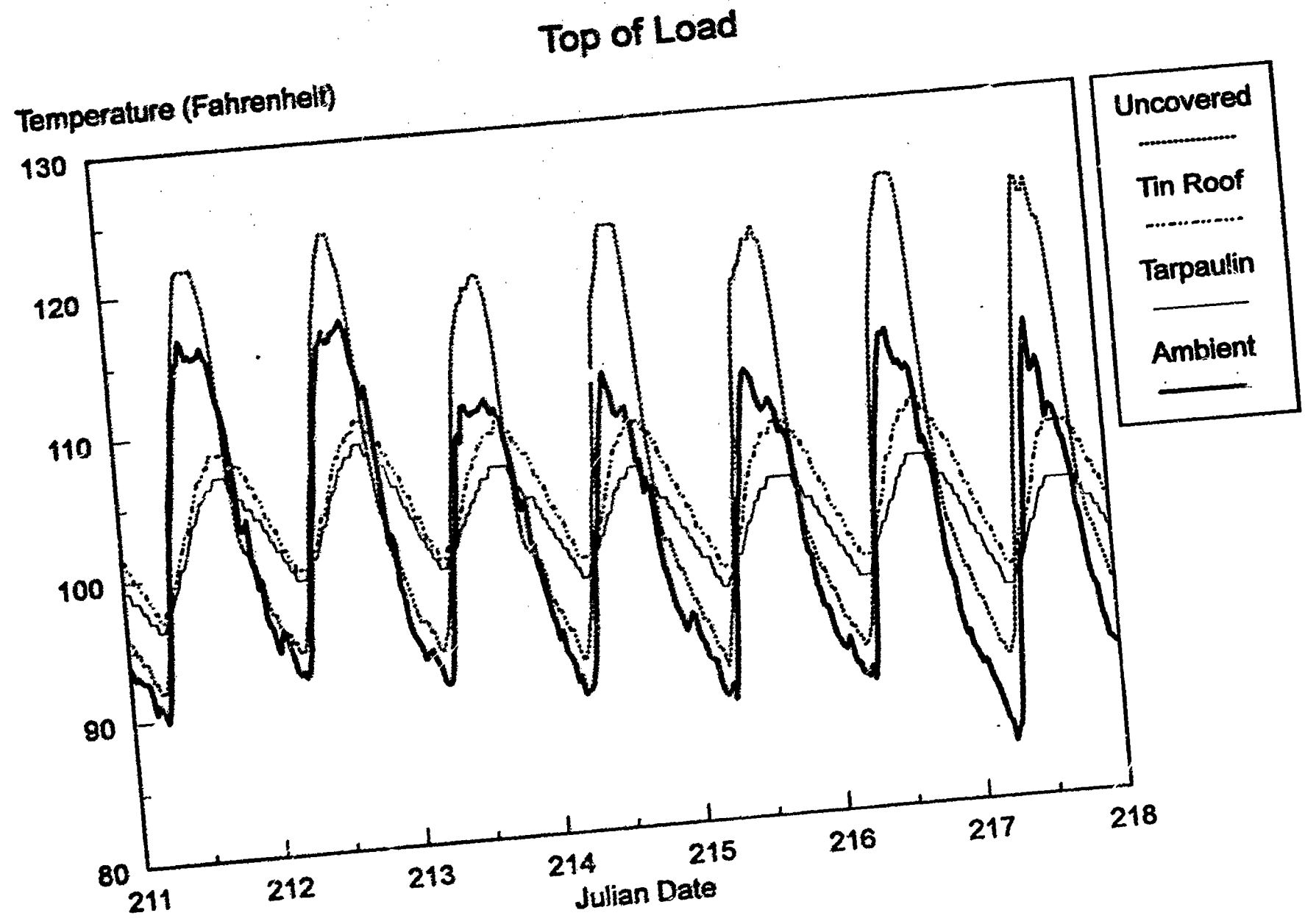
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
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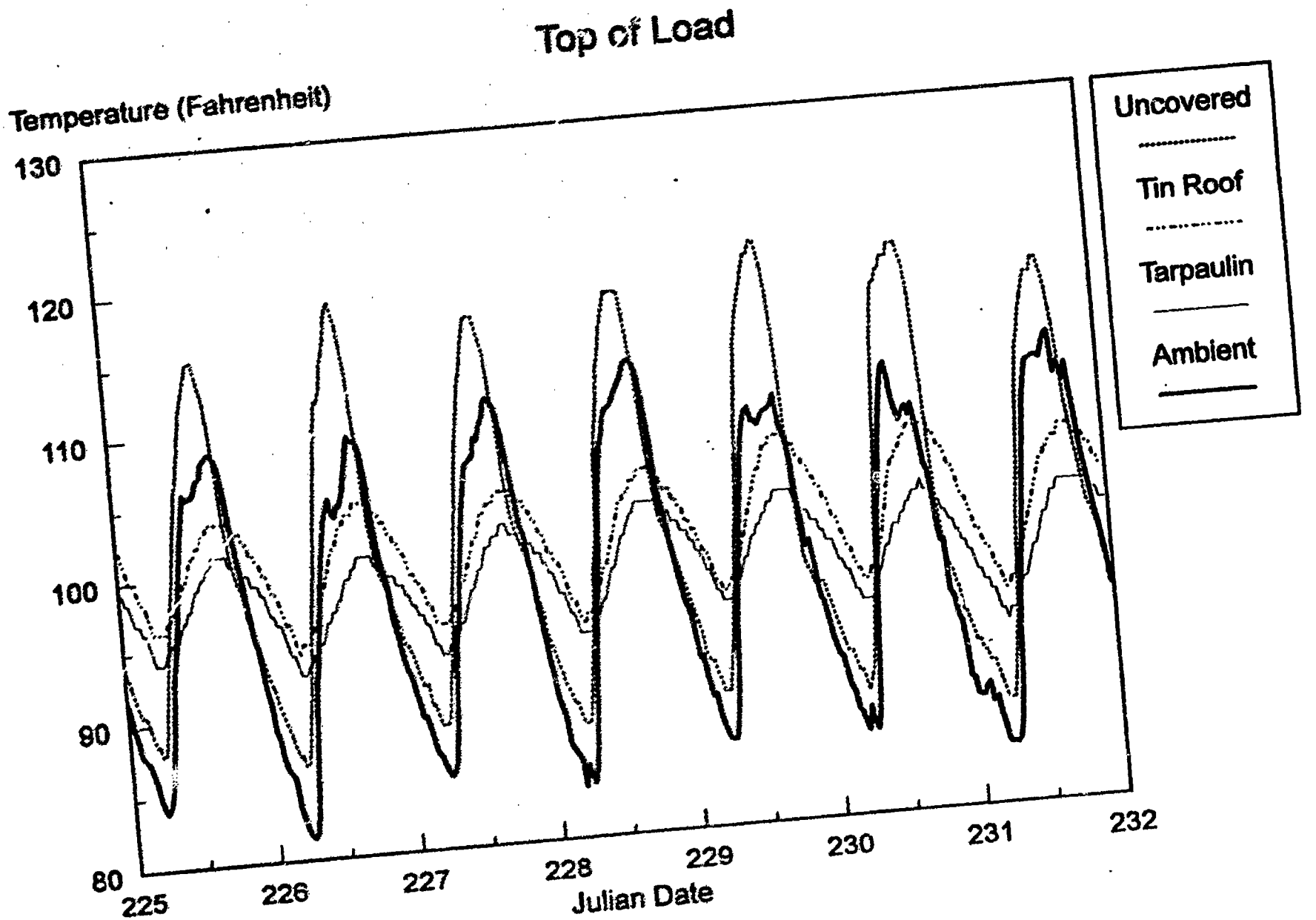
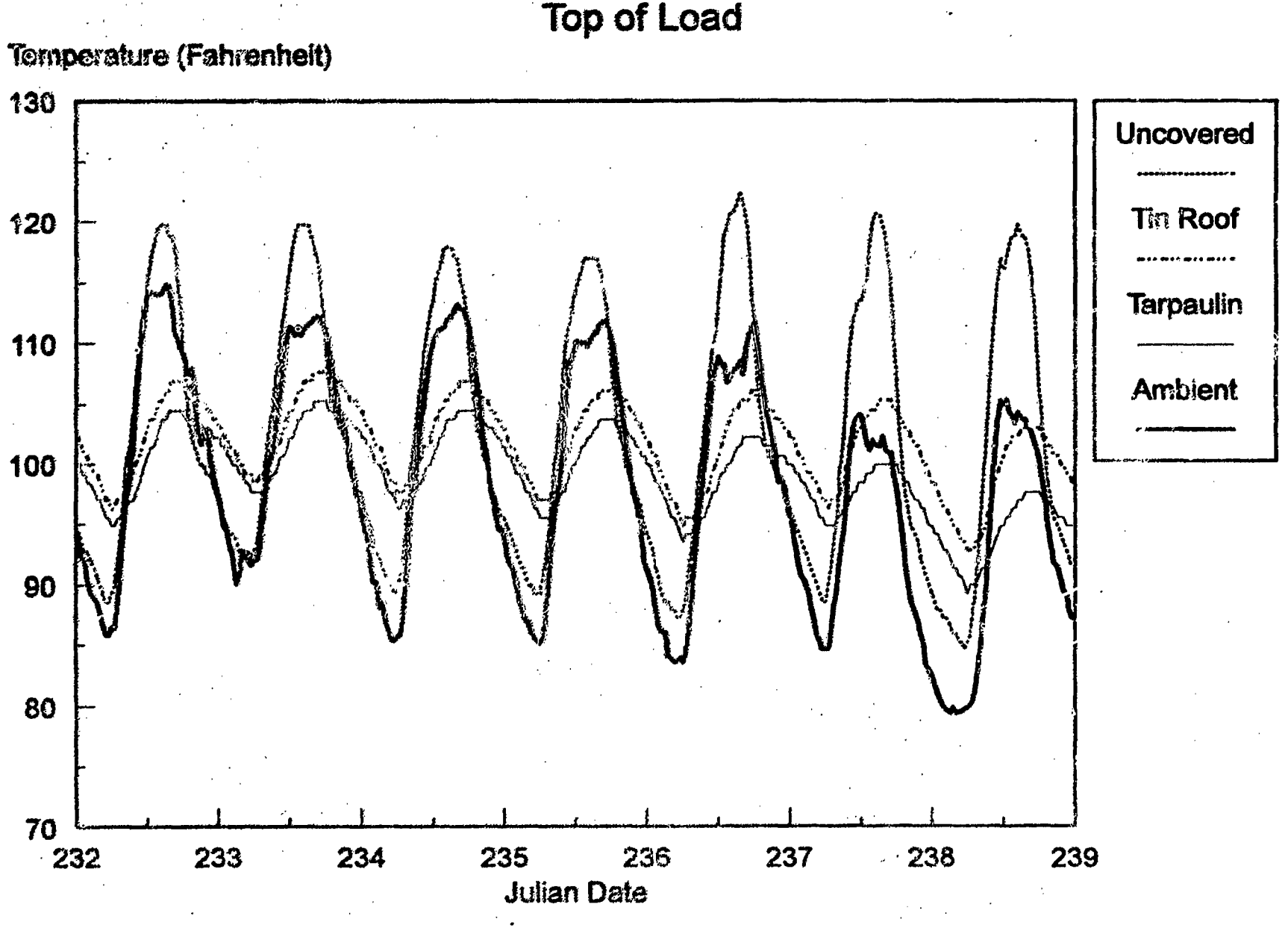
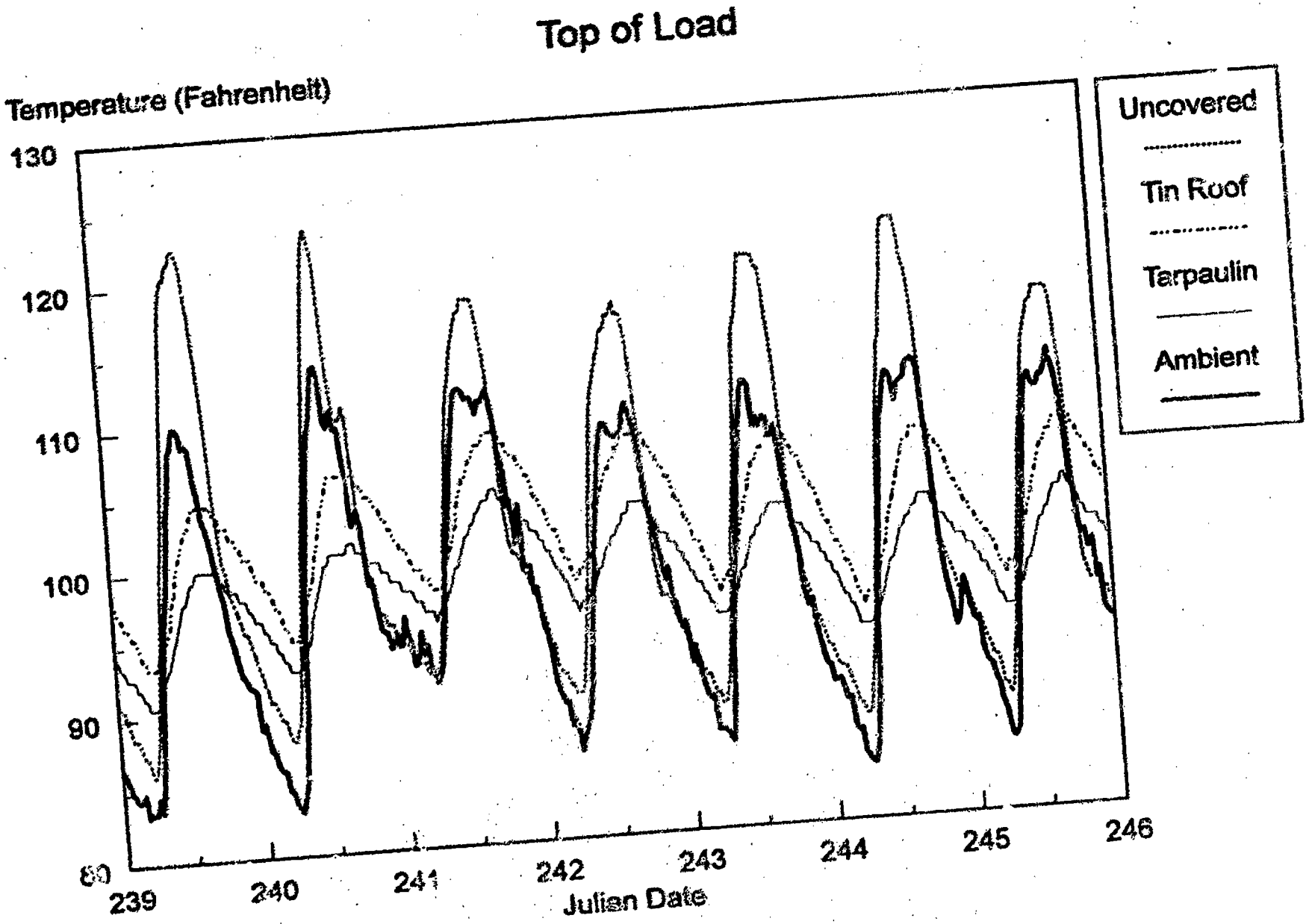
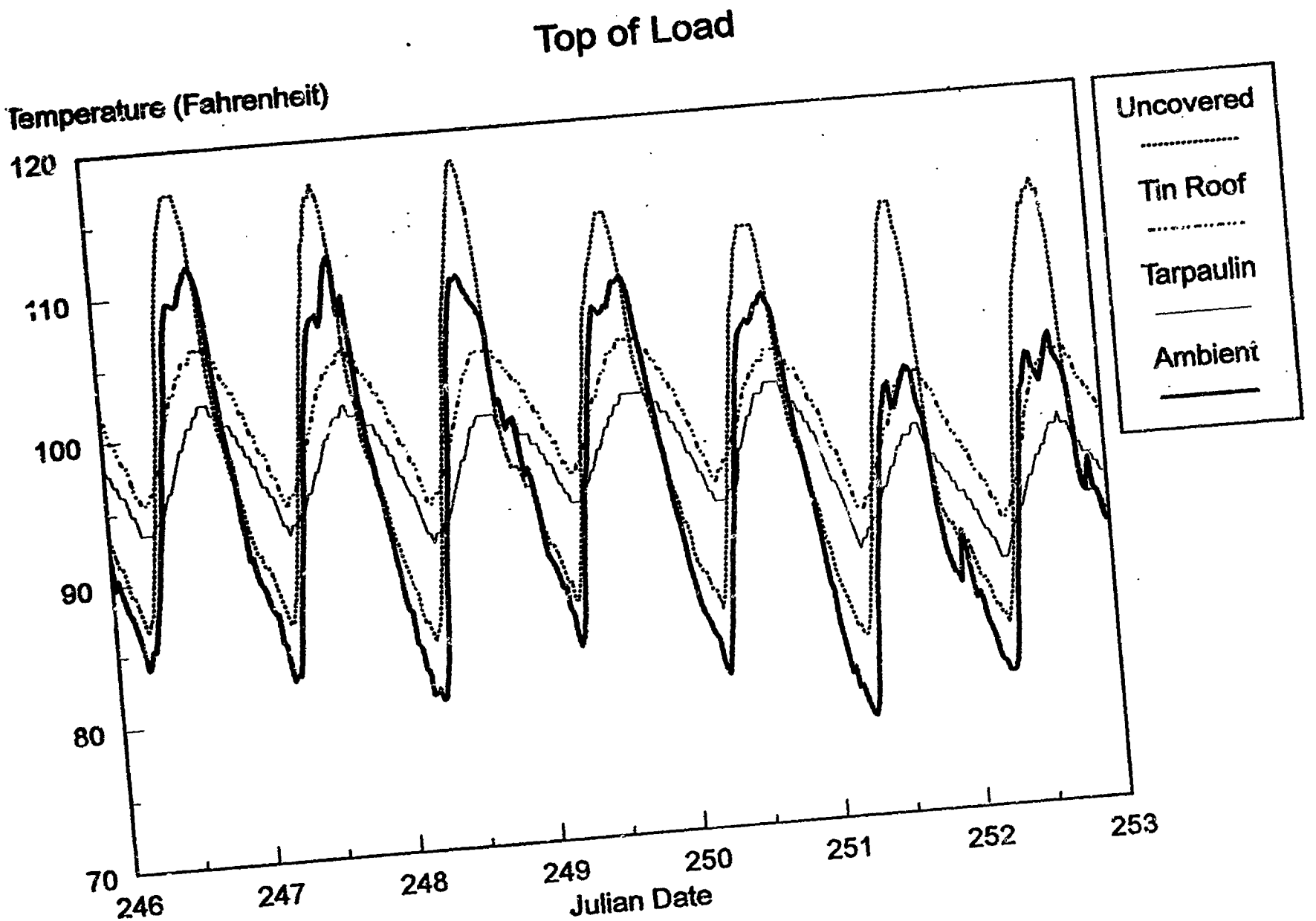
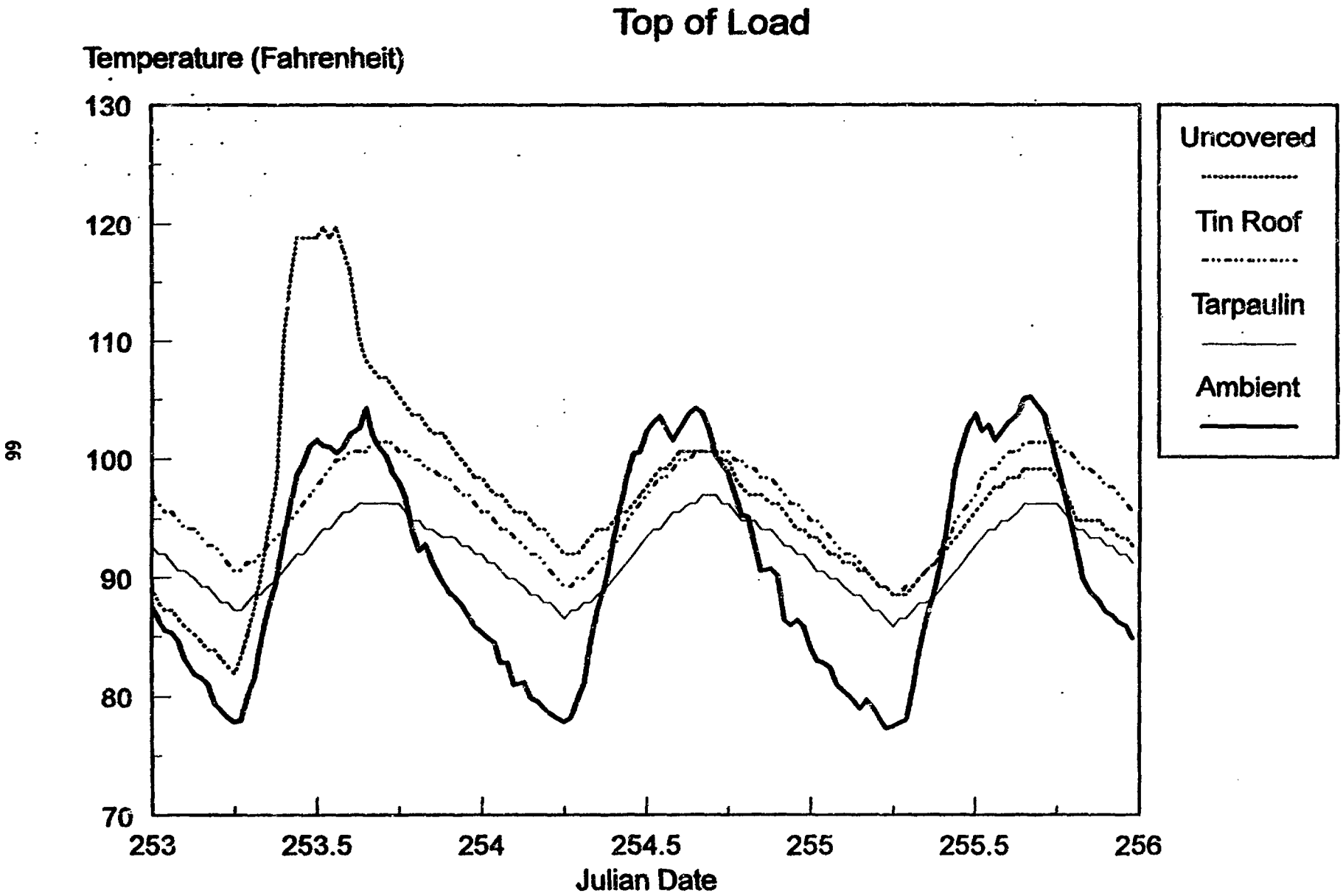
216
217
218
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
130
120
110
100
90
80
225
226
227
228
229
230
231
232
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
130
120
110
100
90
80
70
232
233
234
235
236
237
238
239
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
130
120
110
100
90
80
239
240
241
242
243
244
245
246
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
120
110
100
90
80
70
246
247
248
249
250
251
252
253
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient


Top of Load
Temperature (Fahrenheit)
130
120
110
100
90
80
70
253
253.5
254
254.5
255
255.5
256
Julian Date
Uncovered
Tin Roof
Tarpaulin
Ambient